SCIENTIFIC AMERICAN SUPPLEMENT. No. 1676

Entered at the Post Office of New York, N. Y., as Second Class Matter.
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Published weekly by Munn & Co. at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York

Scientific American, established 1845.
Scientific American Supplement, Vol. LXV., No. 1676.

NEW YORK, FEBRUARY 15, 1908.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

ILLUMINATING GAS.

By Charles H. Hodges.

Of the many industries that occupy important places in American industrial life, there are few of which the public is so ignorant as that of the manufacture of gas. From time immemorial it has been the constant effort of man to devise artificial means of producing light, and with the progress of civilization his efforts have been rewarded, slowly but surely.

As the blazing pine knot was superseded by the candle, which in turn was supplanted by the oil lamp, so the latter has given way then to the kerosene lamp and to illuminating gas.

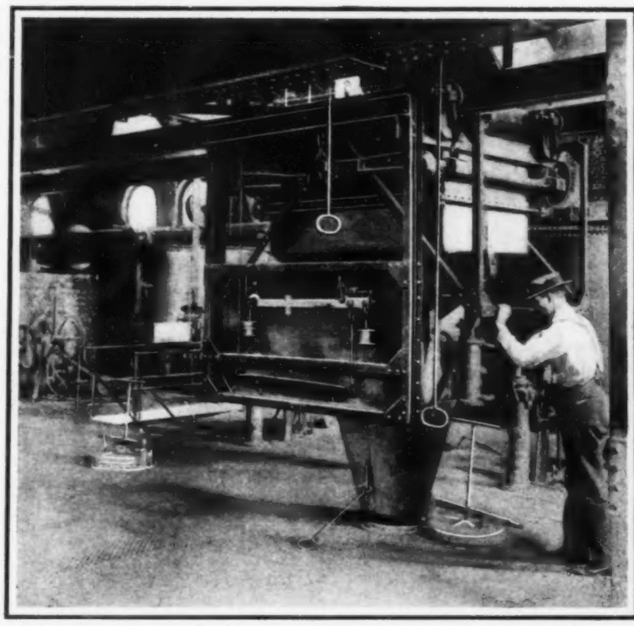
The merit of discovery and application of artificial gas belongs to Great Britain, and the man whose name is most conspicuously connected with its original production is William Murdock, a Scotchman. In 1792 he undertook a series of experiments to determine the properties of gases given off by various substances, which eventuated in the establishment of coal gas as an illuminating agent.

A conservative estimate places the amount of gas manufactured in the United States in 1860 at 4,014,081,000 cubic feet. In 1900 the annual production had increased to 67,093,553,471, the last ten years of the nineteenth century showing an increase of 83.7 per cent. Two years later these figures had grown to 89,458,071,298. Figures up to date show a corresponding increase of production. Of thirty gas plants only could the United States boast in 1850. The year of 1890 saw 742 plants in operation, and by the end of the following decade 135 more had been built.

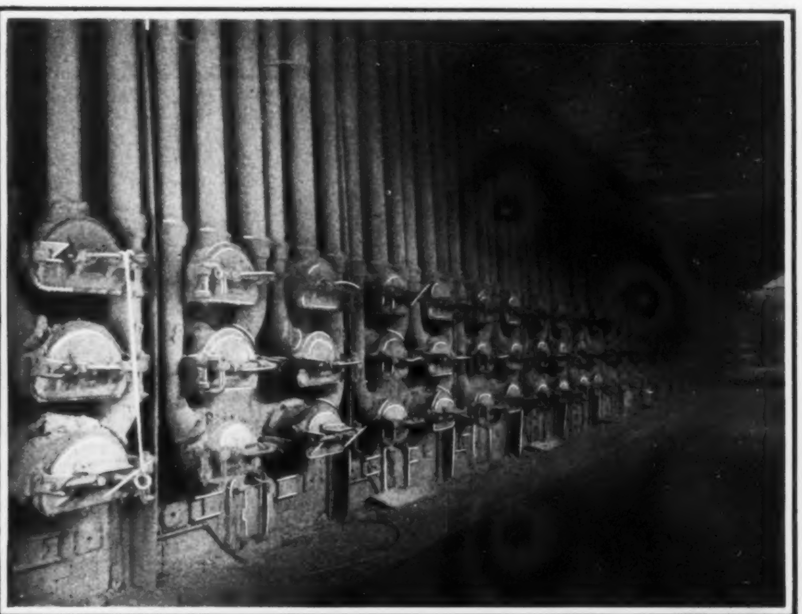
The two kinds of gas most commonly used are coal gas and water gas. The former is produced from a very rich grade of bituminous coal; the latter, by the actual union of steam and anthracite coal.

In the manufacture of the first, coal is heated to a very high temperature in sealed clay retorts. Destructive distillation takes place, the coal giving up its gases, which are rapidly drawn off and purified.

The coal-gas plant is commonly called the retort



THE APPARATUS FOR CHARGING A WATER-GAS GENERATOR.



THE RETORT HOUSE, SHOWING ARRANGEMENT OF RETORTS.

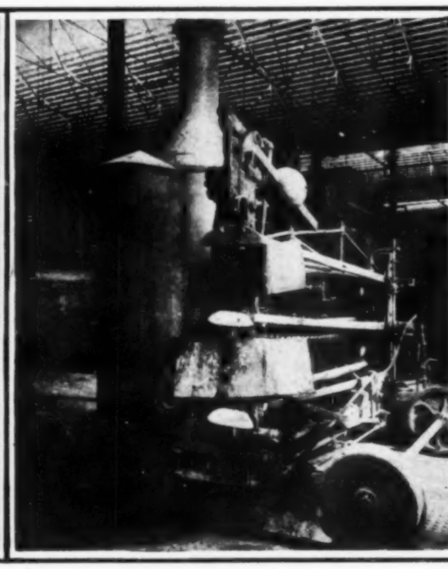
THE PHOTOMETER ROOM, SHOWING THE APPARATUS FOR DETERMINING THE CANDLE-POWER OF THE GAS AND DETECTING ANY REMAINING IMPURITIES.

THE GIANT METERS FOR REGISTERING THE GAS AFTER THE LAST STAGE OF ITS MANUFACTURE.

THE MANUFACTURE OF ILLUMINATING GAS.

house. Upon entering it, one is struck with the prevalence of soot and dirt, which seem to be everywhere. Floors, ceiling, walls, machines, and men alike are coated with black. The place is noticeably warm, the heat radiating from the stack, a large brick structure in the center of the building extending its entire length, and honeycombed throughout with retorts about the size of a coffin, set horizontally and sealed on the outside by iron doors. These retorts usually contain about 300 to 400 pounds of coal, and are heated by a furnace in the lower part of the stack. The retorts must be cleaned out and refilled every four or six hours. This is done by automatic machines. Originally, this work was performed by hand, and necessitated ten times the labor now required. It is an interesting operaiton. The retorts are arranged in the stack in three rows, one above the other. As each retort door is opened, a tongue of flame shoots out, accompanied by a loud explosion, which is caused by the instantaneous combustion of the gas remaining in the retort and the outside air. Along the front of the stack runs a track. With almost human intelligence and precision the discharging machine, upon which is mounted a man acting as engineer, now moves down on the track to a point opposite the nearest open door, thrusts its three rake-like arms into as many retorts, and draws out the coal, now transformed into glowing coke, leaving the retorts bare as if swept by a broom. The coke falls through openings in the floor, and is immediately quenched in the cellar below. The machine then moves down the track to the next three retorts, while directly behind it comes the charging machine, and which by an operation the reverse of the previous one fills the retorts with coal. This continues until all the retorts are emptied and refilled.

PURIFYING HOUSE WHERE SULPHURETED HYDROGEN IS REMOVED FROM THE PRODUCT.



MACHINE FOR DRAWING COKE FROM THE RETORTS.

THE MANUFACTURE OF ILLUMINATING GAS.

The begrimed men, the rattle of machinery, the glowing coals and flaming retorts combine to make a weird and lurid picture, not unsuggestive of an inferno. The retort house now becomes quiet, like a huge monster settling down after a full meal.

As blood is produced from food taken into animal bodies, so gas is generated from coal heated in the retorts, the great digestive organs of the gas plant. The gas passes off and up into the "ascension pipe" by which it is led to a long narrow covered tank half full of water, known as the hydraulic main. Here the first steps in its purification take place. The ascension pipe dips about an inch into the water, and the gas bubbling up to the surface is condensed, robbed of part of its tar and some of its ammonia and hydrogen sulphide.

From the hydraulic main it is drawn off through a condenser, where it is chilled, and most of the remaining tar held in suspension is precipitated. It next passes on to the ammonia tower, a tall narrow building inclosing a lattice-work arrangement or loose coke, through which trickles a stream of water. As water will absorb from five to six hundred times its volume of ammonia, the gas is quickly relieved of that impurity. The resulting ammonia liquor after being concentrated is sold to handlers of the product, who purify it for the market. The gas works are the chief commercial source of ammonia. Both tar and ammonia are important and valuable by-products. From the first are obtained medicines, pitch, the splendid aniline dyes, and many other commodities.

It may surprise the reader to learn that moth balls are but compressed "naphthalene," a substance which tar at a certain temperature yields in the form of beautiful white crystals.

The gas being now ready for the removal of its last and most objectionable impurity, sulphureted hydrogen, well known to chemists by an odor resembling that of rotten eggs, is passed through a series of box-like compartments filled with shavings and iron oxide—common iron rust. When the gas comes in contact with this mixture, a chemical change takes place. The iron combines with the sulphur, forming iron sulphide, while the hydrogen and oxygen combine to produce water.

Freed of its sulphureted hydrogen, the now purified gas is forced through giant meters about eighteen feet in diameter, and finally into the holders, to be stored until needed for use. From the holders it is either delivered directly to the city or pumped through underground pipes to other holders for distribution.

The gas holder is a large hollow structure, cylindrical in shape and made of sheet iron. It may be compared to a gigantic tomato can with one end open. Resting in a tank of water with the open end down, and held in an upright position by a surrounding framework, it moves up and down according as gas is let in or drawn out. All the larger holders are made of several sections, which telescope into one another in such a way as to prevent any escape of gas. It is the weight of the holders that forces the gas to our homes.

Before entering the larger street mains after leaving the holder, the gas passes through governors, so adjusted as to insure as near as possible an unvarying pressure at all times throughout the city. Upon reaching the consumer the pressure is about an ounce to the square inch.

Between the meter and the holders a small pipe runs off to the photometer room, where the candle-power of the gas is determined. The walls of this room are painted a dead black to prevent the reflection of light rays, and every precaution is taken to prevent the entrance of outside light and drafts. In the center of the room is a table, at one end of which is a lamp of known candle-power, while at the other end burns the gas that is to be tested. By the use of an intermediate translucent disk, which travels on a graduated scale between the jet and the lamp, the relative intensity of the two flames is accurately determined. This operation is merely an application of the law that the "intensity of light" varies inversely as the square of the distance from the source of light.

In the manufacture of water gas, air and steam are alternately passed through a deep fire bed of anthracite coal or coke. Air is forced through under pressure and heats the fuel to incandescence. The steam in turn combines with the heated coal to form water gas. But as the product thus obtained burns with a blue flame, producing heat but no light, it must be mixed with vaporized oil, either crude oil or one of its distillates, in order to acquire illuminating properties.

That steam could be decomposed by incandescent carbon was known more than one hundred years ago. An Italian named Fontana published in 1780 the results of his experiments upon the dissociation of steam, but the gas produced being non-luminous, it was regarded as a laboratory curiosity only.

During the civil war, Prof. I. S. C. Lowe was engaged in making balloons for the United States government. While striving to develop an economical method of producing gas to supply his wants, he invented a process for the manufacture of water gas. Later he conceived the idea of vaporizing petroleum in the presence of this gas. This was the germ of discovery that was destined to revolutionize the methods of making illuminating gas.

The first floor of a water-gas plant contains a series of large vertical cylinders, symmetrically arranged in groups of three or four, each group comprising a water-gas machine. The cylinders are from 8 to 12 feet in diameter, and extend from the floor to the ceiling, a distance of about 20 feet. When there are but three cylinders to a group (as in the accompanying cut) they are arranged in a row, and are known respectively as the generator, the carbureter, and the superheater. The latter projects through the second floor, rising to the height of about 10 feet above it. On this floor is attached the mechanism by which the machines are operated. A pipe connects the lower end of the superheater to the lower end of the carbureter or middle cylinder, the upper part of which is joined in a similar manner to the upper part of the generator. The generator is the furnace of the gas machine. It has a capacity for several tons of coal, which is let in from the top through an opening in the floor. Both the carbureter and the superheater are filled with fire brick arranged to present to the gas as much surface as possible. To the top of the carbureter is attached an oil spray.

Each machine is operated by a man stationed on the second floor in front of the superheater. He first turns on the blast. A draft is let in near the base of the generator, and passes up through the coal bed, which thereby is raised to a very high temperature. The burning gases pass up and over into the carbureter, then downward through the cylinder and up through the superheater, finally going out at an opening in the top of the latter called the stack. As long as the draft is maintained, the machine is said to be blasting. It is continued until the brickwork in the last two cylinders is raised to a very high temperature. The draft is then shut off, and the steam from a pipe leading from a near-by boiler is forced up through the fuel beds. The blast outlet is closed and the oil spray is turned on. Upon coming in contact with the heated brickwork the oil is vaporized. The steam passing through the fuel beds in the generator undergoes a chemical change, combining with the coal, and non-luminous water gas results. This is saturated with oil vapor in its journey through the two following cylinders to an outlet in the shape of a large pipe attached to the upper part of the superheater. The process continues until the temperatures of the fuel bed and brickwork are greatly reduced, when the blasting is begun again.

Some machines are provided with two generators, in which case the two cylinders are arranged side by side, and are both connected with the carbureter.

The gas thus made is purified in very much the same manner as coal gas, with the exception of the removal of ammonia, which the former does not contain. After being measured in the large meters, it is mixed with coal gas in the holders for distribution.

About a ton of coal is fed into the generators every hour. A small car especially constructed, holding about 3,500 pounds of coal, with a funnel or chute attached to the bottom, is used for this purpose. Provided with wheels running on an overhead track, it is operated by one man, who with comparative ease pushes this car along until it is directly over the lid of a generator. The lid is then removed. Scales are attached to the coaling apparatus. After weighing about a ton, the operator lets that amount drop into the generator below, by the movement of a lever.

ACETYLENE, ALCOHOL, AND POWER.*

THE POSSIBILITIES OF ACETYLENE AS A MOTOR FUEL.

BY T. L. WHITE.

It is very seldom that an industrial art can maintain fixed bounds, either as to its methods of production, or the marketing of its products. Also, the changes, often radical, which arise, usually come in a very adventitious and unexpected manner. For instance, some industries have been superseded by more modern methods, and then revived, owing to a once valueless by-product of the old process coming into demand.

In the case of calcium carbide, we have a substance whose utility to date is that of an efficient light-producer. Of course the actual source of the light is the acetylene, but as the carbide is the actual market product I speak of it now and in the sequel as a light-producing, power-producing, etc., substance, as the case may be, the intermediary processes being understood. It seems that, owing to a coincidence of circumstances, each in itself outside the present scope of the carbide industry, a stage has been reached in the evolution of prime movers which will bring carbide straight to the front as a power-producing substance, and, if this view is right, the demand for it in its new capacity will far exceed the present demand for it for all other known purposes. To clearly establish this proposition, if I may so term it, it will be necessary to traverse briefly the fuel question, to indicate the tendencies in motor construction which obtain to-day, and thence to show how, owing to those very qualities of acetylene which have hitherto prevented its use in explosion motors, it seems destined to take its position as a fuel adjunct, supplementing the defects of what all indications promise will be the fuel of the future, namely, alcohol.

1. The majority of existing explosion motors to-day—and there are over four million in the United States alone—were evolved under gasoline conditions, and are, at the present moment, gasoline-burning instruments. In other words, the internal-combustion engine has grown to its present perfection on the assumption that gasoline could be, and would continue to be, available, of good quality, and at a reasonable price. However, there has recently arisen a very serious and vital change. Gasoline is the by-product of a geographically limited and monopolistically controlled industry; and, to quote the findings of a commission recently appointed in England to look into the fuel question, "There is not the slightest doubt that, in the immediate future, we will be face to face with a gasoline famine." This being so, it is incumbent upon engineers to find a substitute for gasoline; and the claims of alcohol as heir apparent seem indisputable. We are then confronted with the following dilemma—on the one hand, millions of motors, built to consume gasoline; on the other hand, a fuel which must be substituted for gasoline, which is unsuitable for use in the existing motor. In brief, alcohol is not gasoline, and differs so radically from it that we have either to rebuild all our motors, to burn the new fuel, or we must do something to the new fuel which will bring it under gasoline conditions.

2. Without going into any technicalities of gas engine construction, it may be taken as axiomatic that so far as efficiency is concerned it is of the utmost importance that the fuel in the cylinder of an explosion motor be burned once and for all, at the moment of maximum compression, i. e., at the dead center, when the spark occurs. This ideal is easily attained in motors of high speed and low compression, when gasoline is the fuel employed, for gasoline is a very quick-burning substance, and very inflammable when mixed even with a very widely varying proportion of air. But alcohol is a slow-burning substance; when mixed with air it is not nearly so inflammable as gasoline, so that, to take as typical an ordinary automobile engine, instead of being burned at the beginning of the stroke, not only is it burned during the whole stroke (which alone, to quote Dugald Clerke, is sufficient to cut the efficiency of a motor in two), but a large proportion of the alcohol escapes through the exhaust without having had a chance to be burned at all.

We now come to the reasons why carbide appears as a remedy whereby the combustion of the alcohol may be conducted so as to parallel that of gasoline.

In the first place, alcohol containing water up to 25 per cent evaporates integrally, that is to say, the vapor has the same proportion of water as the main supply from which it is evaporated. In the second place, if air is carbureted (mixed mechanically) with alcohol vapor, and passed through a bed of carbide, we have resulting a practically intermolecular mixture, with the alcohol, water and air, of a small percentage of acetylene, diffused uniformly throughout the combustible body.

Again, if water can only be introduced into the cylinder of a motor in a proper manner and within certain limits, its presence is advantageous, so that the addition of water to the alcohol, which, in the first place, was made to obtain a reaction with the carbide, is afterward not disadvantageous, but the contrary. Further, the prime property of acetylene is its endothermic energy. This means that when in the cylinder of a motor we have a compressed charge containing diffused acetylene, when the spark occurs the rise of pressure is such that the whole composite body of gas is at too great a pressure for the endothermic energy of the diffused acetylene molecules to remain latent. Consequently every molecule of acetylene present detonates simultaneously with the spark, we virtually have accelerated combustion started by each molecule of acetylene, the alcohol is burned up immediately, and the card of the engine in which this occurs shows as rapid a rise in pressure as is found in the same engine with gasoline.

Again, while it is an advantage to introduce diffused water into the charge of a gas engine, this advantage, in practice, has hitherto been limited by the fact that the presence of such water beyond a certain percentage retards combustion. However, under the conditions which I have just detailed, the dynamic quality of the acetylene secures the necessary combustion speed, and permits of the beneficial presence of water in proportions which would otherwise be impossible or impracticable. As the theory of water in a cylinder, or rather the recognition of the benefit accruing from its presence, is somewhat recent, I would state that it is now accepted that alcohol containing 10 per cent of water is a better fuel under any conditions than absolute alcohol; also that combustion in perfectly dry oxygen is impossible; also, there is no doubt that a sufficiency of water in the charge in an explosion motor cylinder maintains heat in the cylinder which would otherwise flow into the water-jacket and be lost. Also, very high temperatures are not a desideratum in a motor, and whether it be through its latent heat, or whatever else the cause may be, water in the charge is beneficial in this connection as well.

It would, then, appear that the two objections to acetylene as a fuel for motors, which have obtained up to to-day, namely, its uncontrollable violence in exploding and its high cost, seem, under the new conditions, to have vanished. In fact, the first objection takes the aspect of a positive advantage, and the second tends to be eliminated, because the gain in bulk of the fuel, owing to the added water, which costs nothing, offsets the cost of the carbide consumed.

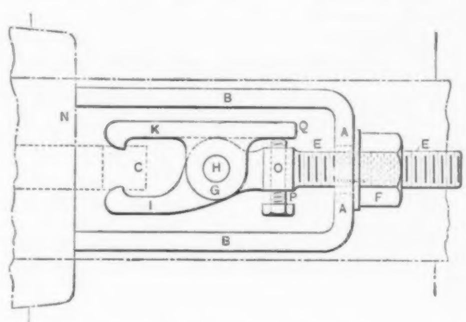
To sum up, the happy combination of circumstances is as follows: Water and alcohol evaporate integrally. Second, alcohol and water, when in contact with carbide for however short a time, take up a small portion of perfectly diffused acetylene. Acetylene is too quick in the motor; alcohol is too slow; and the small quota of added acetylene detonates the alcohol with the rapidity of an air-gasoline mixture. Lastly, the necessary water for the operation, which might be a grave disadvantage, fortunately happens to be exactly the reverse; and, further, with the aid of acetylene, we can use more water than under any other conditions. Incidentally, the heat attending the union of water and carbide, which is the chronic bug on all acetylene generators, is here advantageous, for it vaporizes the alcohol and prevents condensation on the carbide.

An engine has been built to demonstrate in practice the proposition embodied above. Consequently, I have made no attempt to go into figures, as figures from the running engine are what count. However, in case there should be an inference that all that has been said is still in the region of pure theory, it may be added that tests were made during the early part of this year on a De Dion-Bouton $3\frac{1}{2}$ horse-power motor with a low compression, and that, even at 2,250 revolutions, which is very high, a perfect card was obtained, which even surpassed the gasoline card, both in perpendicularity of the ignition line and in the initial pressure.

* Paper read before the International Acetylene Association.

KEY-EXTRACTING DEVICE.

The accompanying cut from the Mechanical Engineer shows an English patented device for extracting keys from their seats in pulleys, etc. The device consists essentially, as seen from the cut, of a bridge piece, a screw supported by the bridge piece, and a clamp adapted to grip the key. The bridge piece *A* has two legs, *B*, the ends of which rest against the boss of the pulley or other object from which the key *C* is to be extracted. A screw, *E*, provided with a fine pitch thread passes freely through a hole in the bridge piece, *A*. On the outer end of the screw *E* is mounted a nut *F*. The inner end of the screw is provided with a boss, *G*, and with an arm, *I*, for gripping the key. Through a hole in the boss, *G*, is passed a pin, *H*, which pin carries the arm, *K*, forming the gripping jaw opposite the arm *I*. The extreme ends of the jaws are provided with inwardly projecting V-shaped edges which engage with grooves formed in the vertical sides of the key, *C*. These grooves must be provided for in the key before it is originally driven into the keyway of the pulley. The screw *E* is also provided with a boss, *O*, through which passes a set screw, *P*, bearing against the heel *Q* on the arm *K*, so that on turning the set screw the jaws are caused to grip the key. The device can lie very close to the shaft when it is required to extract a key from a boss located on the lineshaft. When the parts are engaged in the manner just stated, the nut *F* is turned on the screw *E* with a wrench, and the legs *B* are forced against the boss *N* of the pulley or other object from which it is wanted to extract the key. A further turning of the screw withdraws the key from the keyway. The device, during use, rests upon the shaft carrying the pulley.



KEY-EXTRACTING DEVICE.

FENCE POSTS MADE DURABLE.

The value of creosote as a wood preservative has just been emphasized once more in a note published by the Forest Service. The greatest merit of creosote is that it renders inferior woods serviceable, and so helps to conserve the rapidly diminishing supply of cedar. Among the suitable woods are cottonwood, aspen, willow, sycamore, low-grade pines, and some of the gums. When properly treated, these woods outlast untreated cedar and oak.

Impregnation with creosote has been greatly cheapened by the introduction of the "open tank," which can be installed at a cost of from $30 to $45, or much less if an old boiler be used. A tank with a bottom 12 feet in area will suffice for treating forty or fifty 6-inch posts a day, or double this number when two runs per day can be made. The absorption of creosote per post is about as follows: Eucalyptus, one-tenth gallon; willow, two-tenths gallon; sassafras, ash, hickory, red oak, water oak, elm, and maple, four-tenths gallon; Douglas fir, quaking aspen, and black walnut, six-tenths gallon; sycamore, cottonwood, and lodgepole pine, seven-tenths gallon. The price of creosote is about ten cents per gallon in the East and Middle West, sixteen cents per gallon on the Pacific coast, and 27 cents per gallon in the Rocky Mountains. The cost of treating a post will therefore vary from four to fifteen cents. Properly treated, it should give service for at least twenty years.

Experiments show that with preservative treatment the durability of lodgepole pine in Idaho is increased sixteen years. The cost of creosote is there relatively high, yet by treating posts there is a saving, with interest at 6 per cent, of two cents per post yearly.

According to Power, 80 per cent of the sulphur production of the world comes from Sicily.

MAKING LOW-PRICED MACHINES.*

SUGGESTIONS FOR THE FOUNDER.

BY WALTER J. MAY.

To produce low-priced goods it is necessary that large numbers should be made at one time; that they should be in set sizes, with as many interchangeable parts as possible; that the minimum total cost of labor should be incurred; and that the material used in construction should be so far economized as to have a good article with the minimum of weight. A low-priced article need not necessarily be a useless one, or one incapable of doing a certain amount of work; but, owing to economies in production, it will not be equal to a first-class, high-priced piece of workmanship. If you have a scrap-brass article which has been ground, polished, and lacquered, it will look well, and to many people will appear as good as a thing that has been worked up by hand, and then burnished and lacquered; but, while being genuine enough, the scrap-brass article neither costs so much, nor has it the actual value of the more expensive production. At the same time, you will sell a dozen cheap articles where you will only sell one expensive one; and you must remember that if carpenters' handsaws cost only sixpence each, there would not be a great demand for files.

The production of cheap goods does not mean the employment of low-priced labor; rather the reverse, as you want to turn out each article at the lowest cost, and to do this all charges must come in and be borne by the salable articles turned out. As a rule low-priced labor is synonymous with inefficient labor, and you get so large a proportion of wasters turned out that these more than cover any saving in wages paid when their total cost is considered. Quick and efficient work, combined with a lack of mistakes (?), is what is really required to secure cheapness; and, speaking from a general standpoint, the low-waged employee cannot supply these points in working. Of course, repetition work is monotonous; but there are advantages in it, as practically it is done automatically.

Where cheap goods have to be produced, the first thing is to make careful drawings both of the completed article and its component parts, at the same

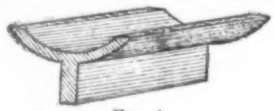


Fig. 1.

time studying where wear and stresses take place. After the drawings are made they should be gone over with the view of effecting two things—the saving of labor, and the reduction of material; and in these there will very often be found a large field for the exercise of ingenuity. Very simple things often effect large economies—as, for instance, in ribbed castings, if such exist. Take as an example the form shown in Fig. 1. Such a section would draw the sand when the pattern was lifted from the mold, and cause a lot of work; but make it of the section as shown in Fig. 2, and it would leave quite cleanly, while the strength would not be appreciably lessened. With gilled motor-cylinder castings, of course, this form would not be used; but even then, with some patterns, very considerable improvements could be made without reducing the efficiency or strength of the cylinder, although making the casting both easier and cheaper to produce. Where articles have to stand on a table, the base should be so made as to stand firmly; and this can be arranged either as shown in Fig. 3, or by having only the bottom edges of the base planed, and the center hollowed out. Where articles are held down with a clamp, the arrangement should always be as in Fig. 3, as this gives the firmest hold, while economizing both labor and material.

In many cases there is no real necessity to finish parts all bright, and in such cases castings should be cast recessed somewhat, so that paint or enamel can be applied over a filler, to make the cast skin smooth enough for the enamel to be quite smooth when finished. Practically, where flanges and edges of machines are finished bright, and a hard paint in keeping with the purpose of the machine covers the other parts, the machine looks as well as when everything is finished bright. But it must be borne in mind that, while this is the case, and a very large saving is effected, if the article has to stand much stress there is always the chance of a fault being hidden which would be shown up if the part were machined all over. Take a cylinder-cover, for instance, and fancy what would happen if a piece were blown out. If the casting were sound, everything would be all right; but usually under paint one expects to find filling in the casting itself.

In cheap work, boring is often done at one cut, soft metal being used, and for this reason careful coring is necessary with castings, and sand should not get into the face of the metal. With wrought work the holes will be drilled from the solid, as a rule, and so long as the pieces dealt with are accurately forged, the work presents no difficulty.

Where such is an advantage in regard to the saving

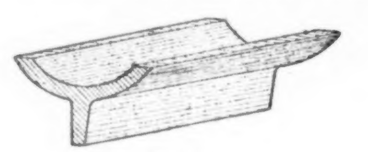


Fig. 2.

of labor, malleable castings may often take the place of forgings, and, assuming that the castings are of good quality, they will stand a lot of knocking about. In fact, for some purposes malleable castings are practically as good as forgings, and cost quite 50 per cent less—a point for serious consideration.

Brass journals in cheap work should have wide flanges at the ends, even although they be really thin; and if made as shown in Fig. 4, they are effective in appearance, while being of small weight. Bushes can be made with a flange on the outer side, and this can be countersunk; but in this case the metal should be hard enough to wear well. In fact, whether made from new metals or from old scrap, all bearing brasses should be hard enough to wear well, and in regard to this some notes will be given later.

Where articles are made of several pieces, each piece should be made to gage; and where drilling has to be done, jigs should be used where necessary, and, where this is not done, metal templets should be used. Probably this means a large first cost; but it reduces the costs in actual manufacture very considerably when large numbers of pieces have to be dealt with.

Instead of forging a great many things at a large cost, stamping can be adopted, and when finished the articles cost far less than when hand-made. Tinware and other light sheet metal can be pressed very largely, and in this form looks better than when cut and soldered; but necessarily large numbers of similar pieces must be produced to pay for the making of the press tools, it being simply the production of large numbers that secures the greatest economy.

So far as metal is concerned, that which is most suited for the purpose in hand should be used, and, as mentioned before, the weight or bulk of metal in any article should be arranged to prevent waste. With cast iron, several qualities should be used for general work, soft iron having the preference where there is much machining to be done, provided that it is reasonably suited for the purpose to which the article is to be used. Galvanized metal should always be avoided, however, as not only is it useless in itself for castings, but it also spoils the other metal with which it is melted. Scrap iron should always be sorted into several grades, and some kind of rough work should

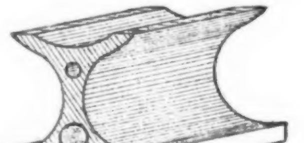


Fig. 3.

be found to use up the rough stuff—sash-bars, boat-ballast, and such-like things taking all the rough, unsalable stuff, provided a sale can be found.

Brass and gunmetal can either be made up as needed, or scrap can be used; and for cheap work this latter is usually of sufficiently good quality. Rough scrap can usually be bought at a fairly low price if unsorted, and anyone having some general knowledge of the alloys used for various purposes can sort rough scrap in a manner to produce almost any kind of metal required; but necessarily no guarantee of strength can be given with castings made from scrap metal. In all cases old bells should be thrown out and melted separately, these being eventually used for hardening purposes, as generally they are about one-fifth tin. Phosphor-bronze should be kept separate also when it is secured of good quality, as this alloy usually is of good strength. Old taps and cast-brass gas fittings are usually the poorest stuffs one gets in brass scrap, while drawn and rolled work is the best, and between these there are a good many grades. As a rule, scrap-brass castings will not stand dipping before lacquering, as in most cases there are both iron and aluminium in their composition. For this reason, grinding and polishing has to be done, and any burnished parts should be carefully worked up so as to avoid staining the other portions, and the whole should be left clean for the lacquer. Where gunmetal or brass bearings are concerned, they are better, and machine easier if from one to two per cent of lead is in their composition; but this adds weight rather than bulk to the castings, and its addition should be carefully considered. For a good many things a lead-antimony alloy is all that is needed, and as this casts freely, and at the present time should cost less than brass, its use for bearings might well be much extended; but it is a white metal, and does not look so well as brass.

Wood parts of any kind should be of good shape and appearance, and should be polished by some cheap process—possibly by a brush polish being put on. If painted, a hard enamel paint should be used, and the articles should be left clean and free from spots and smudges. In fact, this applies to all kinds of painted work, and it is quite possible to make the difference between a quick and slow sale by the manner in which an article is finished.

Whether for home or export purposes, all goods should be finished to take the eye of the prospective purchaser; and this is not necessarily an expensive thing to do, particularly as there are modern processes which cost only a fraction of the older ones. The

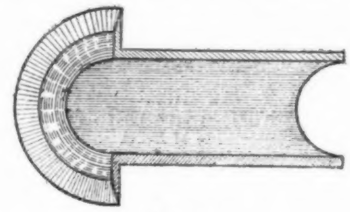


Fig. 4.

emery-wheel will take the place of the planer in large numbers of cases, for instance, and on well-made castings or forgings the appearance is as good, although the surface may not be quite so true. So with many other of the mechanical processes; but necessarily modern plant must be used.

To turn out work well and cheaply, a well-built and light workshop, or series of workshops, will be very essential, and the arrangement should be such that the crude material enters at one end and passes out in a finished state at the other without any unnecessary labor in its passage through the works. Every time you lift or otherwise handle anything, you add to its cost; and this should be borne in mind when dealing with any class of manufacture. Each department of the works should be arranged for the greatest convenience to the workers, and every part should be in full view of the person in charge, for very obvious reasons.

Good tools should be provided, and these should be kept in order at all times, and also kept at work, or otherwise there will be a loss. If you have your own foundry, such things as face and angle plates, and the like, should be made to suit your work and the tools to which they can be applied, and, where such would lead to economies, special tools and fittings should be made. A lot of this will be odd-time work, and when there is temporary slackness in other work; but in any case it pays to make things for general use.

Power should always be ample, whatever method of generation is adopted, and this for the simple reason that if you have not a sufficient power you cannot keep your machines—and, incidentally, your men—fully employed. Every machine should work to its full capacity, and every employee should put in his full quota of work; but in securing this end there is no reason to adopt sweating systems: rather use the motto, "A fair day's pay for a fair day's work." Your employees will respond to this, as a rule; and when you get a "tired" individual—well, give him a rest at his own expense. Your men will respect you for this.

When making low-priced goods, you must never have

* Abstracted from the English Mechanic.

slack times in your works, or your work people will get slack. If you cannot find profitable work for the slack periods, then just make things that carry no profit, and keep on moving. Take in outside work, if possible, or make stock if you know the demand will come; but, anyhow, keep busy. In slack times, go over things and see what improvements you can make, or new things you can introduce; and bear in mind that it is the live man that gets on. Don't sit and helplessly twiddle your thumbs because trade is slack, but just get up and hustle around, and find something for which there is a demand, and which you can make.

ELEMENTS OF ELECTRICAL ENGINEERING.—XI.

DIRECT CURRENT SYSTEMS OF DISTRIBUTION.

BY A. E. WATSON, E.E., PH.D., ASSISTANT PROFESSOR OF PHYSICS IN BROWN UNIVERSITY.

Continued from Supplement No. 1674, page 70.

WITH a suitable equipment of dynamos for generating electricity, on the one hand, and a widely distributed assortment of lamps, motors, etc., on the other, there are next involved the engineering devices for connecting them together. It is, of course, important that one customer's use of the current does not interfere with that of another, that safety to person and property be guarded, and that the effects of interruptions or accidents in the service be minimized. Then too, the system of conductors, with their protective devices, is one of considerable financial magnitude, as is shown by the fact that their cost often exceeds that of the entire generating plant from which the energy comes.

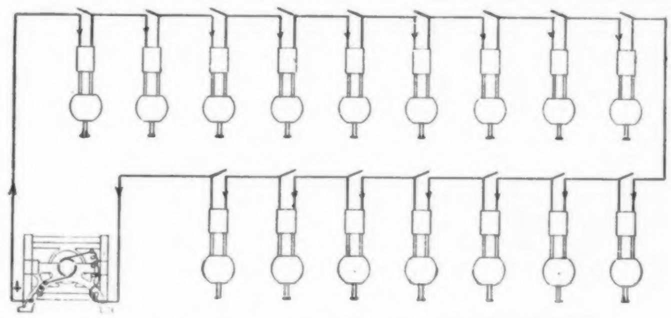


Fig. 40.—Ordinary Arc Dynamo Circuit With Lamps in Series.

Series arc lighting circuits were the first to be commercially operated. Though their management is one still attended with some difficulties, the general scheme is easily understood, and will first be described. Fig. 40 represents an arc dynamo with its lamps connected, as stated, in series with each other. Whether these be imagined as comprised in one room, distributed throughout a factory, or widely separated in city streets, the same current passes in turn through each lamp, and except for possible leakage at the insulators, each will give equal illumination—the one farthest from the dynamo is served just as well as the one nearest.

In Chapter IV. mention was made of the automatic device that prevents a faulty lamp from opening the entire circuit. The extinction of a single lamp at once locates the trouble, but if an entire circuit were interrupted the awkwardness and expense of examining every lamp before again getting re-established would be well-nigh intolerable. To put out a lamp it can simply be short-circuited, and in case of "trimming" with a new set of carbons, the switch at the top of the lamp is closed. If the current were on, it now finds a ready path from one terminal to the other; even if the line is "dead," the closing of this switch is often a prerequisite to releasing the clutch that feeds the carbons; then in case the current comes on, danger to the trimmer is lessened. In the diagram, all these switches, shown directly over the lamps, are represented as open—the right position for lamps to be lighted.

For out-of-door lamps, especially, where danger from defective insulation is most often encountered, and for all such series lamps, to allow for complete removal, for repairs or otherwise, without interrupting the entire circuit, "absolute" cut-out switches are used. Three such are shown diagrammatically in Fig. 41. The two upper ones can be considered as placed on the outer wall of a building; from one, the wires continue to another similar switch conveniently located beside a motor; from the other the wires may lead to lamps. In construction, the switch may be made of a bar of fiber swinging on a central pivot. Strips of thin sheet brass, nearly semi-circular in shape, are riveted

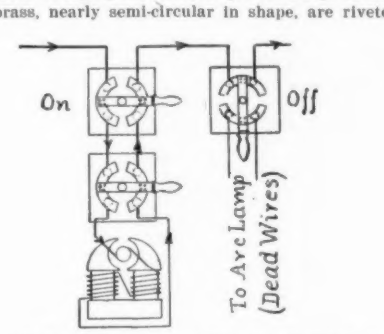


Fig. 41.—Series Motor on Arc Circuit, Showing Also Inside and Outside "Absolute" Cut-out Switches.

on as shown, and make sliding contact on four buttons. Arrows clearly show the entire path of the current for the "on" position; for the "off" position, it will be seen that the house wires merely make contact with the buttons that are entirely out of the house circuit.

For the old open arc lamps taking about 10 amperes of current, wires No. 6 or No. 8 in size are usual. In the average case of street circuits this may represent a loss of 5 per cent of the total energy of the dynamo; but even if the circuits were short, aerial wires of smaller size would not have sufficient tensile strength to withstand the various stresses brought to bear on them. With underground wires, especially for connecting the $6\frac{1}{2}$-ampere inclosed lamps, a smaller size, say No. 10, may sometimes be permissible.

A simple numerical example will illustrate the method of figuring the size of wire for a given set of conditions, and may be interesting to the reader. Suppose fifty 10-ampere arc lamps, each normally requiring 45 volts, are in series on a circuit six miles long. If a loss of 5 per cent is permissible in the line wiring, what size should be used? $50 \times 45 = 2{,}250$; this number represents the useful volts, i.e., 95 per cent of the whole. $2{,}250 \div 0.95 = 2{,}370$, the total number of volts to be generated by the dynamo. $2{,}370 - 2{,}250 = 120$, the number of volts allowable to lose in overcoming the resistance of the line wire. Since the current is to be 10 amperes, and by Ohm's law $C = E \div R$, or $R = E \div C$, the corresponding number of ohms will be $120 \div 10 = 12$. With a length of six miles, the wire should then have a resistance of 2 ohms per mile. Looking in the tables of sizes and resistances of copper wires this is seen to be No. 6 (B. & S. gage). The use of No. 8 wire would be found to represent a loss of over 8 per cent, and require dynamo to generate a total electromotive force of 2,450 volts. Aside from the question of mechanical strength of the wire, the most economical size can be computed from a law of Lord Kelvin's.

This states that the most economical size of wire is the one on which the interest on the investment just equals the cost of the energy wasted. To apply the law to the case just considered, No. 6 (bare) wire weighs 420 pounds per mile, or for 6 miles, 2,520 pounds; at 30 cents per pound, the cost would be $756, and the annual interest at 5 per cent, $37.80. The loss by heating the wire could be determined by multiplying the lost volts by the current, or more commonly by Joule's law, i.e., C^2R watts, or $10 \times 10 \times 12 = 1{,}200$ watts $= 1.2$ kilowatts. Many central stations generate the energy at a cost of about $2\frac{1}{2}$ cents per kilowatt; for twelve hours per day, or rather, per night, and 365 nights per year, the cost would then be $131. Comparison of these figures is suggestive of one reason for the general substitution of $6\frac{1}{2}$-ampere lamps for the 10-ampere sort, thus bringing the loss down to $55 per year. The aim is also to generate the current at a lower cost by employing very large generators of the constant potential sort rather than by continuing the use of the relatively small and uneconomical constant current series machine.

For street lighting, incandescent lamps are sometimes connected in series like arc lamps. Indeed, in some cases the two sorts are to be found on the same circuit. The filaments are short and have a cross section as large as that of a toothpick. More often, these incandescents would be in circuits by themselves and operated by alternating currents. In either case, however, the possibility of opening an entire line of 150 or more such lamps by the breaking of one filament must be guarded against. The simplest device was one invented by Prof. Elihu Thomson, and is called the "film cut-out." Within the lamp socket is a flat brass spring and a somewhat dull brass point; if these two parts are allowed to come in contact with each other, the lamp is short-circuited; in normal condition, a bit of very thin parchment paper separates them, but in case of breakage of the filament, the sudden rise of potential, due to the self-induction of the generator, at

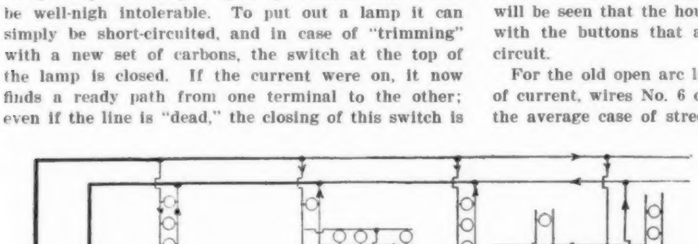


Fig. 42.—Ordinary 2-Wire Multiple Incandescent Lamp and Power System.

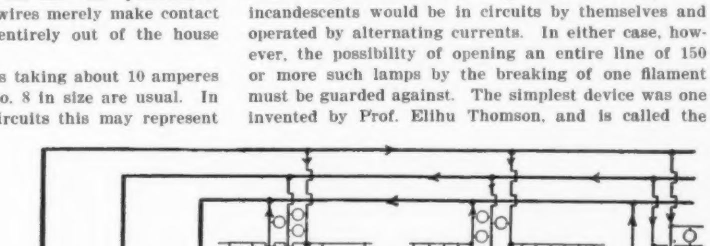


Fig. 43.—Ordinary 3 Wire Multiple Incandescent System, Slightly Out of Balance.

once punctures the paper and re-establishes the circuit. The act of removing the lamp with its socket allows other contacts to maintain the continuity of the line, and a new lamp with its parchment film can be quickly and safely substituted.

The defects of series connections for electric lamps for general use consist in the necessary employment of dangerously high potentials and in the fact that a given circuit is associated with some one particular generator; unless that one is running, there is no light to be had. During hours of small loads it is usually possible to operate several circuits from one machine, or by further switchboard manipulations to substitute one generator for another, but the flexibility of the system is not great.

For the proper operation of domestic and other interior lamps, connections in multiple, or parallel, alone supply the desirable features. Such a system finds its analogy in gas and water piping. The gas cocks and water faucets are in multiple, that is, their combined effect is to provide a multiplicity of outlets, each one fairly independent of the rest. The supply may come from common reservoirs; the pressure is always on, and the service is to be had at any time. The amount that flows is entirely dependent upon the size of the outlet, and when the outlets are closed, all expense presumably ceases. Indeed, the analogy of fall in pressure with increase of distance and load is also obvious. When a great demand for water or gas occurs in a certain locality, friction in the pipes causes a loss in terminal pressure, and water faucets near the top of tall buildings may run quite dry when extra demands are made in the basement. Gas companies commonly compensate for this loss by doubling the pressure at the works, during the evening. Larger pipes and distributed reservoirs are obvious helps in maintaining uniformity of pressure.

In the multiple distribution of the imponderable electric currents far greater sensitiveness is encountered than with the material water and gas. In the layout of a large net-work of conductors, great skill has been exercised to secure the maximum degree of regulation with the least cost of materials, and the reflex action of electrical engineering has taught gas and water men valuable lessons.

In the simplest case of such wiring, two conductors are led from a shunt or compound wound dynamo, and conveniently kept equidistant. Wherever a lamp is desired connection is made with these two wires, and current flows though whatever paths are thus provided. Like the iron pipes of the other systems, the conductors are large where the current is large, but the more the subdivision, the smaller the size of any one wire. Whether current is actually being used or not, the entire system is energized or "live," so that, near or far, any lamp may at any moment be lighted.

Since the full pressure comes to every outlet, some precautions against accidental or malicious uniting of the two mains through a short circuit are essential. In case of a water pipe bursting, the efflux may assume serious proportions, even to the extent of emptying the reservoir. The constant potential dynamo, too, is a device for supplying large quantities of electricity, and it will even ruin itself in the attempt to supply some inordinate demand. Large currents mean great heat and consequent fire, therefore safety fuses of low melting point are inserted at every branching of the current, and whenever the demand exceeds the normal for which the given circuit is proportioned, the fuse is expected to melt, and prevent any worse accident. Naturally some flash is apt to follow the rupture of the circuit, and such fuses need to be inclosed in suitable receptacles of non-combustible material. Porcelain, such as is used for common household dishes, has been found remarkably well adapted to being fashioned in shapes demanded by the increasing rigidity of insurance rules.

In Fig. 42 is given a diagrammatic representation of an extended two-wire system of this sort. From the dynamo (actually, of course, from the switchboard), two separate sets of mains are shown, from one of which, at *a*, *b*, and *c*, various side taps are led off; *a* may be regarded as representing a single cross street, *b* as including some intermediate streets, while *c* is an area completely encircled by the conductors. The diagram could equally well be considered as applied to an isolated or private installation in a residence or factory. The dots are to represent important points for fuses; if in city streets they would usually be located in "manholes." The "fusing" is also found in the cabinets of the house wiring, but not usually to the extent demanded a few years ago; instead of every individual lamp being fused, it is sufficient to apportion them in groups of five or ten. Especially dangerous was the early requirement to fuse combination gas and electric fixtures at the house wall or ceiling. A leaky joint in the vicinity of a flash from a fuse too frequently proved the source of fire.

In the diagram two lamps are represented as close to the dynamo; they may be imagined as pilot lamps on the switchboard. They do not provide a path for all the current, any more than a burner at the gas works let out all the gas, or a faucet in the pumping station drains the reservoir. The one outlet forms a very small path as compared with the entire system. Each individual lamp has a high resistance—in case of one of 110 volts, 16 candle-power, about 220 ohms—while the resistance of the mains to the farthest lamp may be but a small fraction of an ohm. Therefore the resistance of each lamp is so high in respect to that of the copper wires which join them, that for reasonable distances, one lamp gets appreciably the same opportunity for current as any other. It is an old fallacy to say that current takes the shortest path. The correct statement is that the amount of the current is inversely proportional to the resistance of each particular circuit.

The method of computing the proper size of wires for such systems follows the same law as that for the arc lighting circuit, with this exception, however, that as many separate applications need to be made as there are important branching points in the system. "Centers of distribution" would be located, and "feeders" run from the station directly to them, without attaching any service wires, whatever, on the way. Their size might well be checked by application of Kelvin's law; from these centers the "mains" would emanate, pass through the principal streets, be interconnected wherever possible, and from them would be tapped the customers' "service wires." On a smaller scale, the house wiring would imitate this same subdivision.

Since copper does possess electrical resistance, and is a fairly expensive metal, some limit is evidently reached beyond which the expense of delivering current would be prohibitive. Indeed, with simple two-wire systems and moderate potentials, the limit is reached altogether too soon to be welcome. Possibly 1,500 feet from the generator might be regarded as the greatest distance ever successfully reached by any of the early Edison circuits. Incandescent lamps are very sensitive to variations of potential, and in practice, differences exceeding 3 per cent are intolerable. To minimize the expense of copper and enable greater distances to be reached, Edison invented his famous "three-wire" system. On the face, three wires would be considered as costing more than two, and further, the system required that dynamos should always be operated in pairs, thereby somewhat complicating the station equipment. This latter point is still regarded as a defect, and various engineering methods have, in recent years, been adopted to minimize or eliminate the practice. With the three wires, however, there is the substantial gain that they represent far less copper than the other two. Since by Joule's law, the loss in conductors by heating them, varies as the *square* of the current, any means of halving the needed current at once reduces the losses to one-quarter; or, with the same weight of copper, a distance four times as great can be reached with no greater loss.

Edison's invention—though also claimed by Hopkinson—consisted of putting two dynamos in series, each one of full potential, connecting the lamps everywhere two in series, and connecting the junction of the lamps with the junction between the two dynamos. The scheme is clearly shown in Fig. 43. A single path may be followed from the + pole of No. 1 dynamo to any one lamp, then along the central wire to another lamp, through it and back to the — pole of No. 2 dynamo. If in every case lamps could be found "paired," the system would be completely "balanced." In the diagram the group *a* consists of eleven lamps on each side of the system; it requires no current to flow through the middle wire, and as far as the needs of this group are concerned this wire is idle or "neutral." In group *b* there are nineteen lamps on one side, and sixteen on the other, therefore the current for three lamps must get back to No. 2 dynamo by the middle wire. Were this wire omitted, the same current that passed through nineteen lamps would also be compelled to pass through the sixteen, and the two sets would burn with unequal brilliancy; did too great a difference exist, all the lamps in one set would burn out, and thereby also shut the current off from the other set. In the group *c* ten lamps are represented on one side, six on the other; the current from four lamps would pass back to No. 2 dynamo by the middle wire. In the entire system, then, seventy-three lamps are represented as being supplied, yet the current for only nine is required to be transmitted through the middle wire; its size can therefore be less than the other two, in practice being often one-half their size. Station managers use their best efforts to apportion the various taps in such a way as to keep the current in the neutral as small as possible. Motors are always connected to the two outer wires, therefore directly contributing a balanced load.

Since in the three-wire system the same current passes through two lamps in series, or is used twice over, so to speak, only half as many amperes are needed as in case of the two-wire system. For a numerical comparison, with seventy-seven 110-volt lamps the latter would need about 38 amperes, and the dynamo would supply, in addition to the losses, $110 \times 38 = 4{,}180$ watts. In the three-wire system, only 19 amperes would be needed for a completely balanced state of affairs, and the square of 19 is only one-quarter that of 38, therefore the losses in transmission would be one-quarter as great. Just as much power would be exerted by the dynamos in the actual lighting of the lamps, for in this case the two machines in series would be supplying 220 volts, and $220 \times 19 = 4{,}180$ watts as before. Were it not for the neutral, the system would require only one-quarter as much copper as the two-wire; making this third wire one-half the size of the others, still only five-sixteenths as much copper is required, and even with all three wires the same size, but three-eighths as much metal.

If three wires, and double potential, are better than two, why will not more wires be still more economical? Five-wire systems, with 440 volts between outer wires, have actually been installed in Manchester, England, and Berlin, Germany, but the resulting complexity did not warrant the continuance of the method, and the installations have been changed to ordinary three-wire systems. It is now possible to find instances of the use of 220-volt lamps on ordinary two-wire systems, thereby securing the economy of copper without the necessity of using dynamos in pairs. Though the lamps themselves are a little less efficient than those for 110 volts, an engineer might find that for a scattered locality, this disadvantage was of less account than the saving in the size of line wires. The general use of storage batteries in sub-stations has also provided one means of eliminating the "pairs" of dynamos; the neutral is tapped from the middle cell of the battery equipment, and the charging done by single dynamos of double potential. A standard voltage, with allowance for losses in transmission and for charging the full number of cells, is 300. In Providence, R. I., an exceptionally high voltage system is in use. The neutral is tapped from the middle of the battery, as usual, but the normal potential across the two outer wires is 500 volts, and the lamps receive 250 volts each. The charging is effected by the use of ordinary 550-volt power generators. Special difficulties have been encountered in the operation of the system, but they have largely been overcome by ingenious and meritorious methods.

For enabling the heavy conductors to be put underground, Edison devised a cheap and highly effective "tube" system. In this the conductors were inclosed in iron pipes, separated from each other by rope and a tar compound. The different lengths were joined in cast iron boxes, these also finally being filled with the same insulating compound. Water was thus thoroughly kept out of these places by pre-empting the space with insulation. At street intersections, accessible manholes with water-tight receptacles for the fuses were located. The pipes were laid in very shallow ditches, but the defect of the system consisted in the necessity of digging up the streets every time additional conductors were required. Conduits, into which lead-covered cables may be drawn as needed, have been found far more satisfactory.

Railway trolley circuits are commonly of the two-wire sort, the rails and ground being negative. Three-wire connections have been used to a limited extent. In this case, the trolley wires over neighboring tracks have 1,000 volts difference of potential between them, and the ground is neutral. Did railway circuits consist of straight-away lines only, the system might be of great commercial economy, but the necessity of cross-overs, switches, and turnouts makes the difficulty of insulation almost insuperable.

In discussing the three-wire system, care must be taken not to confuse it with the so-called three-phase alternating-current system. The former, whether worked by direct or alternating currents, is understood to mean an arrangement in which the voltage between the two outside wires is twice that between either wire and the middle, that with a balance load, this middle or neutral wire conveys no current, and can be of small size. The three-phase circuit also requires three wires, but the voltage is the same between any two, all three carry equal currents, and therefore must be of the same size. A more adequate explanation of this point will follow in later articles when alternating currents are being discussed.

Chapter XII. will explain some of the more simple switchboard apparatus and arrangements, and the manipulations for allowing a number of dynamos to be operated conjointly.

SUBMARINE CABLES VS. WIRELESS TELEGRAPHY.

THE Electric Review considers that the transatlantic cables are in no immediate danger from the competition of wireless telegraphy. One of the pressing problems which wireless experts must solve is the development of commercially practicable selectivity. Until a number of stations can work side by side without affecting one another, the usefulness of the new system will be very limited. Until this problem is solved, and an equally good transmission by day and night assured, the wireless system will occupy a very minor position.

THE EXPLOSION OF GASES.*

A STUDY IN DETONATION.

The earliest work on the explosion of gases was that of Humphry Davy, who in 1817 published those celebrated experiments on "the propagation of flame through small tubes and orifices" which led him to the construction of the miner's safety lamp.

More than half a century later Bunsen devised the non-luminous gas burner, observing that unless the flow of the mixture of coal-gas and air exceeded a certain rate the flame became unsteady and passed down the tube. Bunsen believed that this rate represented the velocity with which an explosion would travel in the combustible gases in a closed tube, and he obtained definite value for a number of mixtures by leading the gases through an orifice at the end of a tube, igniting the jet, and determining the minimum speed at which the gases must be forced through the tube to prevent the flame passing back through the opening. The rates of explosion measured in this way were comparatively slow, the fastest observed being about thirty-seven yards a second.

But in 1881 Berthelot and Vieille discovered that when an explosive mixture is ignited at the end of a long pipe, the velocity of the explosion rapidly increases from its point of origin until it reaches a maximum velocity, which remains constant however long the column of gas may be, and which greatly exceeds the speeds of combustion measured by Bunsen; this discovery was confirmed by the independent investigations of Mallard and Le Chatelier, published at the same time. Berthelot gave the name "l'onde explosive" (detonation-wave) to the flame traveling with its maximum velocity, thus distinguishing it from the variable progressive combustion which precedes its development. The velocity of the explosion-wave constitutes a physical constant which has a specific value for each inflammable mixture; measurements by Berthelot and H. B. Dixon have shown that it is approximately equal to the velocity of sound in the burning gases at the temperature of the explosion. For a mixture of hydrogen and oxygen in equivalent proportions the velocity is about 3,000 yards a second.

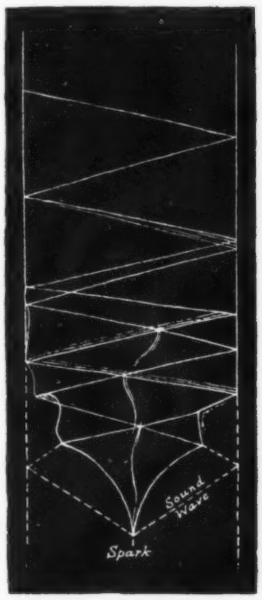
Mallard and Le Chatelier succeeded in recording the slow movements of the flame of progressive combustion by photographing the flash on a piece of sensitized paper fixed on a revolving cylinder. They found that when the gases are ignited at the open end of a long tube, the flame travels for some distance with a uniform slow velocity of the order measured by Bunsen; the flame next begins to vibrate, swinging backward and forward with oscillations of increasing amplitude; then it either dies down or the gas detonates. If the gas is fired near the closed end of the tube, the movement of the flame is uniformly accelerated until the detonation is set up. Le Chatelier's apparatus was not fast enough to analyze the wave of detonation itself.

The apparatus used by Prof. Dixon consists of a drum carrying a narrow strip of Eastman film, which can be rotated at the rate of 100 meters a second. The explosion tube is fixed horizontally, and the image of the flame is focused on to the vertically moving film. In an explosion of cyanogen with oxygen, the mixture was fired near the middle of a tube by an electric spark. The flame moved slowly in both directions; to the left it passed out of the field of view, to the right its speed increased until a detonation-wave was set up. The detonation-wave, moving with constant velocity, was represented by a straight line, while the slower movement of the progressive combustion preceding was shown as a curve, the steepness of which diminishes as the motion of the flame accelerates—the speed of the drum being uniform. The duration of the flash was less than 1/100 second. The period before the detonation is distinguished not only by the slow movement of the flame, but also by slow and incomplete combustion and feeble luminosity.

The initiation of the detonation-wave is marked by certain characteristics—(1) a sudden increase in intensity of the flame, accompanied by an instantaneous rise in pressure; it is found that glass tubes are most often fractured at the point where the detonation originates; (2) rapid and complete combustion; (3) the setting up of a strongly luminous backward wave—the so-called "retonation-wave"—which under certain conditions travels as rapidly as the detonation-wave itself. The sudden rise in pressure is due to the increase of chemical action, and this pressure not only produces the forward detonation, but also sends a backward wave of compression into the slowly-burning gases behind it; this compression-wave raises the temperature of the combining gases and increases the luminosity. It should be observed that the light produced by the explosion is chiefly due to particles knocked from the glass and raised to incandescence; the small particles suspended in the burning gases glow by the heat imparted to them by the hotter but invisible gaseous products of combustion.

The detonation-wave is set up only after the flame has run some distance, which depends on the nature of the mixture and on the size of the spark.

Hydrogen and oxygen was exploded in a closed glass tube too short to allow of the detonation being set up. The gas is fired in the middle of the tube, and the flame spread right and left with faint luminosity. The flame is preceded by an invisible compression-wave which travels with the velocity of sound through the unignited gas, and is reflected from the ends of the tube. The flame is checked while these two compression waves pass through the burning gases, and is then helped forward by the waves moving in the same direction. The movement then becomes unsymmetrical; the flame to the left is checked a second time before it reaches its end of the tube, that to the right reaches the end of the tube and sends back a strong retonation-wave. The wave from the right is of greater intensity and moves more rapidly than that started a little later from the left, and, although the reflections of these waves at first run nearly parallel, the stronger gradually overtakes the weaker and coalesces with it,



MOVEMENTS OF THE FLAME AND COMPRESSION WAVES.

and the single wave continues to traverse the tube from end to end. As many as one hundred reflections have been counted in an explosion of this kind. The accompanying figure shows in outline the movements of the flame and compression-waves.

The flame in its initial stage is only very feebly luminous, a fact which has led to erroneous beliefs in regard to the mechanism of explosion. Von Oettingen and Von Gernet, failing to photograph the flame itself, introduced finely-divided salts into the tube, and obtained brilliant pictures of the explosion showing a series of parallel waves. They believed that the explosion itself was *quite invisible*, the movements shown in the picture being compression-waves rushing through the burning gases after the explosion was completed. These parallel waves, following each other in close succession, were supposed to be due to "successive partial explosions" proceeding from the spark, in accordance with Bunsen's theory of discontinuous step-like combustion.

The influence of water vapor on the combustion of hydrogen with oxygen has formed the subject of much recent research. Some years ago Dixon showed that an electric spark would fire ordinary electrolytic gas whether in the dried or moist condition, and that the velocity of detonation was practically unaffected by the presence of aqueous vapor. The experiments of Baker with very pure hydrogen and oxygen have, however, shown that the initiation of the flame is largely influenced by the purity of the mixture. It might be expected that the initial phase of the explosion (before detonation is set up) would be modified if the interaction of the gases depends on the presence of previously formed water molecules. Dixon and Bradshaw have shown by photographs that this is not the case; the flame, once it has been started by a spark, spreads with the same velocity in the dry as in the moist gases, and undergoes the same changes in intensity. So far as the development and movements of the flame are concerned, the presence of water-vapor appears to make no difference in the union of hydrogen and oxygen.

In a recent paper Dixon and Bradshaw have shown that the compression-wave which travels in front of the flame in the initial stage of the explosion may, under certain conditions, bring about the spontaneous inflammation of the gases in a region of the tube some distance from the spark. They exploded hydrogen and oxygen in a tube one end of which had been drawn off in the blowpipe flame in the manner of a Carius bomb-tube, so that the end had the form of a funnel followed by a short capillary. The explosion started in the middle of the tube; almost simultaneously the gas inflamed in the capillary. The firing of the gas in the capillary was caused by the sudden increase of pressure in the funnel, the heat of compression raising the gases to the temperature of ignition. The wave produced is analogous to the tidal "bore" in a funnel-shaped estuary.

* Abstracted from Nature.

THE EFFECT ON THE LIVING OF THE GREAT EPIDEMICS OF PLAGUE.

Great epidemics of plague not only destroy large numbers of people but they leave their traces on the living. The effects on the living have usually been very marked and very similar. They are mostly psychological and social in their nature. Great numbers of the living are unable to bear the strain of the scenes around them and the uncertainties of life which the epidemic brings too plainly before them. Minds which have hitherto been sober and calm become overwrought, unhinged, and hysterical. Excitability and suspicion are engendered, often leading to illusions, delusions, and excesses of all kinds, which in some instances become contagious and dangerous. The change is not sudden but comes gradually. First of all, the normal courage, solicitude for the sick, hope, and religious trust which belong to the healthy mind are unaffected, but later these are associated with intense pity, exaggerated religious fervor, and the deepest despair. Then they are followed by panic and a total revulsion of feeling in which the predominant features are fear, selfishness, callousness, and heartlessness, and later still, if the scourge continues, there is a display of all the most sordid and worst passions on the part of the unbalanced portion of the population.

Plague, above all disasters, tends to bring out for a time the weak points in humanity and seldom the virtues. Hecker gives an account of the frenzy and mania caused by the mental strain brought on by the terrible events associated with the Black Death. He describes the doings of the flagellants in Germany, Hungary, Poland, Bohemia, Silesia, and Flanders, who marched through the cities in well-organized processions and who bore triple scourges, tied in three or four knots, in which points of iron were fixed and with which they flogged themselves. Harmless and welcome at first they later became a terror to the inhabitants of every place they visited. He describes also the epidemics of dancing mania that followed and he gives an account of the cruel and fanatical persecution and wholesale massacre of the Jews who were accused of poisoning the wells and thus causing the plague. He says: "Already in the autumn of 1348 a dreadful panic caused by this supposed empoisonment seized all nations; in Germany especially the springs and wells were built over that nobody might drink of them or employ their contents for culinary purposes, and for a long time the inhabitants of numerous towns and villages used only river and rain water. . . . By this trying state of privation, distrust, and suspicion, the hatred against the supposed poisoners became greatly increased and often broke out in popular commotions which only served still further to infuriate the wildest passions." The suspicion and rumors regarding the poisoning of the wells in the Punjab are only the reappearance of a part of the credulity and delusions which prevailed during the time of the Great Pestilence of the fourteenth century.

There were other effects besides these disorders of the mind. The whole social structure became seriously disorganized owing to vast tracts of country becoming waste land and an immense number of huts and houses becoming tenantless. Prices of commodities rose, rents fell, payment of the taxes on land could not be obtained. There were agrarian, labor, and political troubles. Laborers and workmen were scarce and demanded higher wages, and it was found impossible by laws, imprisonment, fines, or any other

methods, to bring them to conform to the older order of things. A new era with a new spirit sprang into existence which in the course of years and after many struggles banished the old.—Prof. W. J. R. Simpson in a paper on "Plague," read before the Royal College of Physicians, London.

A NEW SUBWAY IN PARIS.

By the PARIS CORRESPONDENT of SCIENTIFIC AMERICAN.

AT present there is in construction in Paris a subway line which has some interesting points. The new road is laid out somewhat upon the same lines as the Paris Metropolitan subway, and will make connection with the latter at different points, so that the cars may shift from one road to the other. This new subway line will run in a north-and-south direction across the city. It will take a district which is not covered by the Metropolitan, and will connect the southern quarter with the central part of the town.

The total length of the line, which is entirely underground, is about $8\frac{1}{2}$ miles. It comprises the main line which runs from the Versailles gate, proceeds northward past the Montparnasse depot, then crosses the Seine in tunnel, running thence under the Metropolitan subway and past the St. Lazare depot, finally reaching the northern terminus at the Place Jules Joffrin. At the St. Lazare depot starts a short branch tunnel which passes by five stations and ends at the St. Ouen gate. The main line has twenty-three stations, making twenty-nine stations on the entire route. The tunnel section and the stations are laid out on about the same plan as for the Metropolitan double-track system. There are two special features of the new road. One of these is the steel tube under the Seine and the second the underground stations built of reinforced concrete. The writer is indebted to Director Simon, of the North-South Company, for the following points about the construction:

One of the principal points which occupied the attention of the engineers was that of taking the subway line across the Seine. The existing Metropolitan line crosses the Seine three times on bridges. Another line, which is now in course of execution, is taken under the river; but in this case the engineers sank a number of caisson sections in the Seine which are joined end to end below the river bed, connecting at the same time with the shore ends of the subway.

As concerns the new subway line, quite another method was adopted, the engineers preferring to run a tube under the river by the shield and compressed-air method, introduced into France some time ago in order to take two large sewers under the river. The work of running the tubes for the subway has been commenced. The general course and the profile of the construction is shown in one of the sectional views which shows the tunnel in its completed state. There is a double tube under the river bed, each tube carrying one of the tracks of the road, which are standard gage. The single tunnel which approaches the river on the south bank and which is of standard section for double track, ends at a large underground station lying near the river at Rue de l'Université. At the other end of this station start the two parallel sections of the steel tube. The two tubes are run under the street for some distance and then pass below the Seine in an almost parallel path. Coming to the other bank, the tubes diverge somewhat, and then are brought together and enter a second station. This latter forms the end of the tube section. From the farther end of the station the standard double-track tunnel resumes its course toward the northern part of the city.

The entire length of the steel tube sections is 1,764 and 1,797 feet respectively between the two stations. The two tubes have a slightly different profile, and the tube lying up stream starts from the Université station at a down grade of 4 in 100, and on reaching the river the grade becomes nearly level at 1.5 per 100. Toward the other bank the line mounts again at a grade of 3.51 per 100, with a total length of 538 meters (588 yards). The second tube differs very slightly in level, and its length is 548 meters (599 yards). Both of the tubes have an inside diameter of 5.00 meters (16.4 feet) and an outer diameter of 5.24 meters (17.2 feet). The center of the tube is 1.40 meters (4.6 feet) above the rail-level of the track. The tube is formed of a series of cast-iron rings 2 feet broad bolted together by 1-inch bolts through flanges. Each of the rings is made of curved cast-iron pieces forming voussoirs after the manner of arch construction. Around the circumference there are twelve voussoirs, including the key-piece, which is shorter than the rest. There is a space left between the voussoirs of each ring and also between the different rings of the tube of 5 millimeters (0.20 inch), and the space is filled by a thin piece of creosoted wood, poplar or pine, on the outer side, the inner part being then filled up with a calking of Portland cement mortar. The thickness of the walls of the tube is one inch of metal in the thinner part, this being reinforced by the webs of the voussoir,

A SECTION OF THE NEW SUBWAY, SHOWING HOW WALL THICKNESS HAS BEEN SAVED IN CONFINED SPACE BY THE USE OF CONCRETE. IN PLACES THE SUBWAY TRAVELS UNDER NARROW STREETS AND IT IS NOT PRACTICABLE TO EXTEND ITS BREADTH SO AS TO ENCROACH UNDER THE SHOPS OR HOUSES. HENCE THE SIDES AND VAULTING OF REINFORCED CONCRETE.

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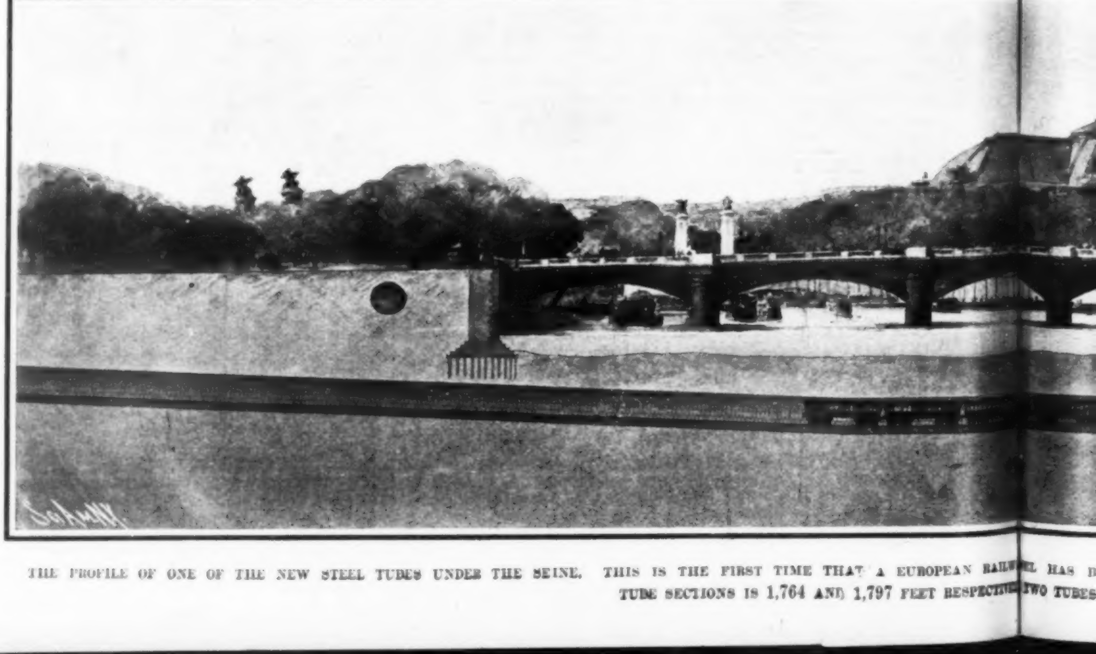

THE PROFILE OF ONE OF THE NEW STEEL TUBES UNDER THE SEINE. THIS IS THE FIRST TIME THAT A EUROPEAN RAIL L HAS
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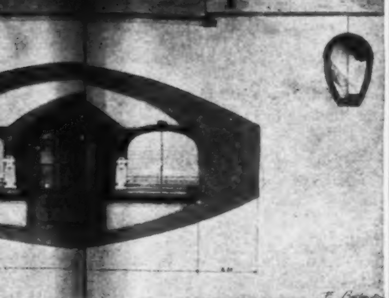

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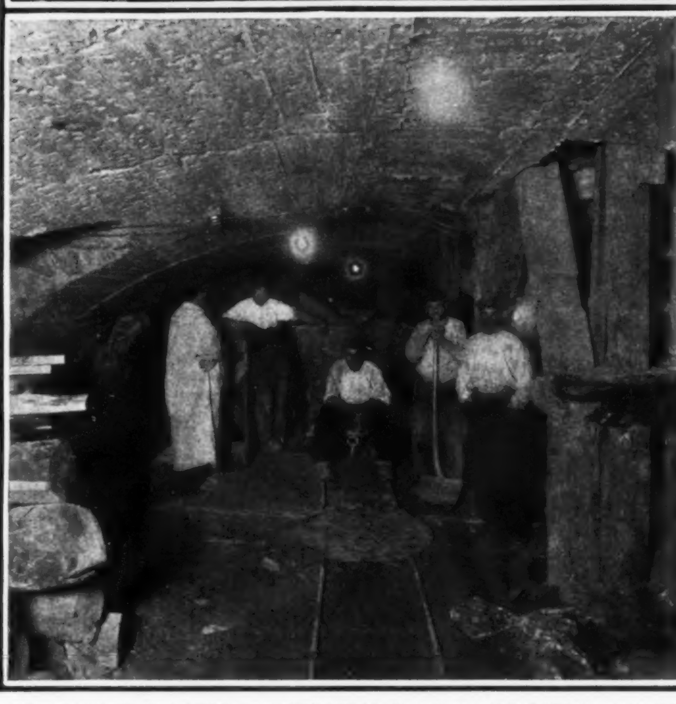
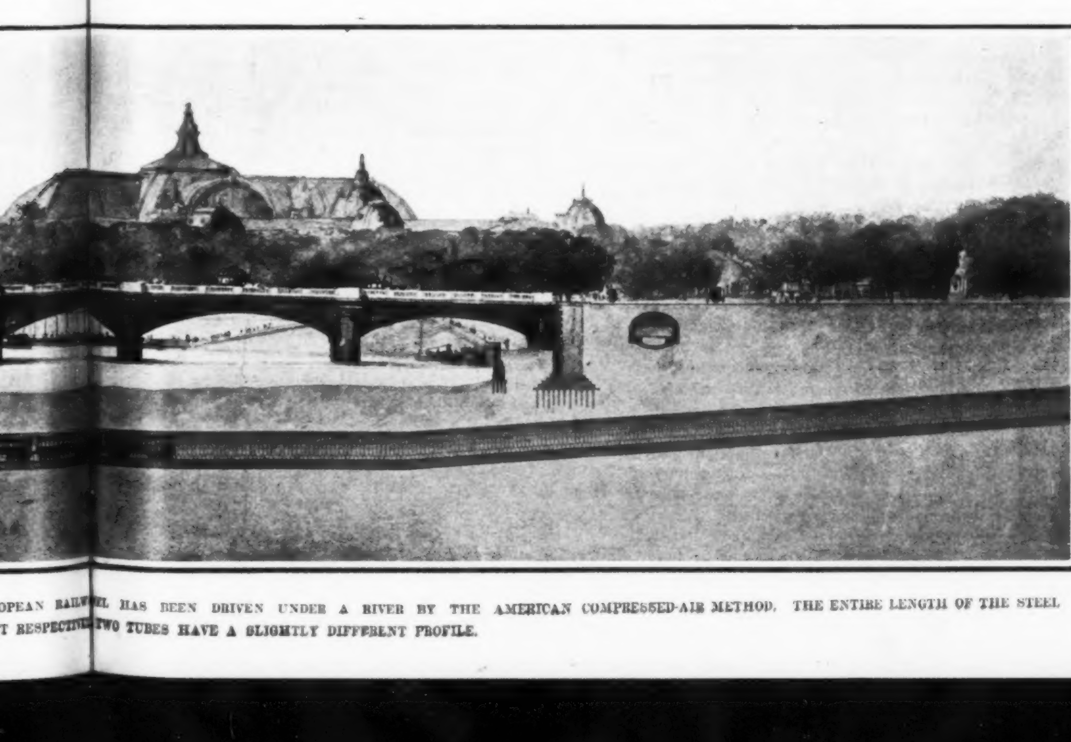


TWO STAGES OF THE WORK OF CONSTRUCTING THE NEW PARIS SUBWAY. THE DISTANCE BETWEEN CENTERS OF THE TWO TUBES VARIES FROM 23 TO 43 FEET, HENCE THE TWO TUBES ARE NOT EXACTLY PARALLEL. THE TUBES WERE RUN UNDER THE RIVER SEINE BY MEANS OF THE AMERICAN SHIELD AND COMPRESSED-AIR METHOD.



OPEAN RAILW L HAS BEEN DRIVEN UNDER A RIVER BY THE AMERICAN COMPRESSED-AIR METHOD. THE ENTIRE LENGTH OF THE STEEL T RESPECTIV TWO TUBES HAVE A SLIGHTLY DIFFERENT PROFILE.

which make the total thickness across the web to be 5 inches. Holes are left in the iron in order to allow for injection of cement around the finished tube so as to fill the space between the earth and the tube and give a protecting covering. To this end the cement is forced into place under pressure through the one-inch threaded holes, using a special apparatus which works at a pressure of three atmospheres. After the filling, the holes are stopped by bolts which are screwed into them. In this way a good covering for the tube is secured.

The distance between centers of the two tubes varies from 7 to 13 meters (23 to 43 feet) and thus the tubes are not exactly parallel. At present the Université station, which is designed to be one of the underground stations of the line after the road is finished, is employed as a compressed-air plant. Here is installed a large outfit of Ingersoll compressors driven by electric motors on the three-phase system. The high-tension electric mains are brought directly to this point, and are run into large transformers which reduce the voltage for running the electric motors and also for the lighting of the plant and the tube section. The compressed air is used for two purposes, first for keeping up the pressure inside the tube and second for working the hydraulic jacks, which cause the advance of the shield. The material is taken out of the tube and through the air-lock by means of small cars which run upon a middle track. After leaving the air-lock the earth is taken out of the station by means of a vertical shaft which connects with a horizontal gallery. The latter is run to the Seine, where it ends in an opening in the quay wall, where the material is emptied into barges. In the same way the cast-iron pieces for the tunnel are brought in from the outside.

One of the original features of the present plan consists in the use of reinforced concrete for the underground stations. This was required in some cases where the streets were very narrow and the station could not be built in the ordinary way without an excessive cost for expropriation. In order to build the stations without interfering with the walls of the houses, the present method was adopted, and in the case of the Rue de Vaugirard, which is only 15 meters (49.2 feet) wide, an underground station 44.6 feet wide has been built without infringing upon the adjacent property. Instead of 7½ feet for the station wall, the reinforced concrete occupies a thickness of only 2 feet. A station is illustrated here, with the principal dimensions. It has a double track and two side platforms, as usual. What is to be noticed is the reinforced cement construction on the Consideré system. The vaulting is only 18 centimeters (7 inches) thick, but is reinforced by webs which are designed so as to lie partly on the inside and partly on the outside of the vault, as will be observed in the section. The views taken during the progress of the work will also show the general plan which is used here. When finished, the vaulting is covered over with a layer of cement, giving a smooth surface. The webs are spaced 1.60 meters apart (5.3 feet). The vaulting lies 1.39 meters (4.7 feet) below the paving level, and the height of the tunnel is 6.73 meters (22.1 feet). As to the side wall, it is built of a general thickness of 0.16 meter (5.2 inches) reinforced at intervals of 1.60 meters (5.3 feet) by webs which give the total thickness of 0.60 meter (2 feet).

ALTERNATING CURRENTS AND MAGNETISM.

Referring to the speed with which magnetism vanishes, Herr M. Gildemeister, of Konigsberg, quoted in the Electrician, says that when iron is subjected to a magnetic field whose intensity is suddenly increased or decreased, the change in the magnetic state consists of two parts: the one a very rapid change, and the other a slow change which succeeds the rapid change after a certain interval. The author investigates the disappearance of magnetization after removal of the magnetic field, within 1/2000 second after break. The method employed is that of Helmholtz, the pendulum being a special one reading to an interval between break and make of 1/600000 second; this interval was taken as the unit. A theoretical discussion of the experiments is given. The conclusions arrived at from the experimental result are the following: In 1/300000 second the rapidly-disappearing magnetization falls to less than half its initial value. In 1/150000 second it falls to less than 1/10 its initial value, and after 1/50000 second has completely vanished, in the case of the very thin wires (0.0185 centimeter diameter). Between 1/50000 and 1/2000 second the magnetization does not decrease perceptibly. With somewhat thicker wire (0.028 centimeter diameter) the magnetization was once observable after 1/40000 second, and with the thickest wire (0.118 centimeter diameter) after 1/7500 second even. This is probably due to the influence of eddy currents. The slow demagnetization apparently does not set in until after 1/2000 second. The wire cores were not used for some days or weeks after annealing.

A NEW ELEMENT, LUTECIUM.

OBTAINED BY SPLITTING UP MARIGNAC'S YTTERBIUM.

BY G. URBAIN.

In the separations of the elements of the yttrium group, I have always observed that ytterbia gives the most soluble salts. The method which seems to me the best for the preparation of this substance, free from yttria, erbia, and thulia, is the crystallization of the nitrates (G. Urbain, Bull. Soc. Ch., 1905, xxxiii., 739; Journal de Chimie Physique, 1906, iv., 31; "Extract from a Communication to Sir William Crookes," May 5, 1906, Proc. Royal Soc., 1907, lxxviii., 154). In 1905 by this method I obtained 50 grammes of raw ytterbia, answering to Marignac's description (Comptes Rendus, lxxxvii., 578).

I propose in this preliminary note to describe shortly the researches which I have been carrying on since then.

In order to determine the atomic weight of ytterbium we are restricted to the analysis of the sulphates of similar products. It seemed to me to be necessary to subject the ytterbia to systematic fractionation in order that I might be sure that its atomic weight and its spectral characteristics were constant.

For this purpose I subjected the nitrates to fresh fractional crystallizations in nitric acid of density 1.3. Thus I obtained, after a very tedious series of fractionations, extending to 22 consecutive fractions, a series of products, the absorption spectra of which I examined first. The first fractions, numbers 9 to 16, showed faintly absorption bands which alone revealed the presence of thulium. I eliminated these fractions. The other fractions which might be considered to be pure ytterbium were transformed into sulphates and analyzed.

Far from being constant the atomic weights varied, gradually increasing from 169.9 for fraction 17 to 173.8 for the last fraction, number 31 (see note). Such a large variation is sufficient to show the complexity of ytterbium.

(NOTE.—For this first approximation I took O = 16, H = 1, S = 32. These numbers would be increased by about 0.17 if in the calculations I had taken O = 16, H = 1.008, S = 32.06. It may be mentioned that the atomic weight of thulium cannot be 171. It is undoubtedly below 168.5.)

I tested the final products of my fractionations for thorium. By the very effective method of Wyrouboff and Verneuil (the action of oxygenated water upon the solution of the neutral nitrates), I succeeded in separating from the earths with the highest atomic weights about a twenty-thousandth of thoria, which could have no influence upon my measurements.

By the arc spectra method I was not able to detect the presence of any impurity in my products thus purified, and there is no doubt that my ytterbia was not a mixture of several constituents.

By photographing on the same plate one above the other the arc spectra of the extreme members of this fractionation, I detected in the spectrum of the last fraction (No. 31) many lines, mostly well marked, which could not be seen in the first fraction (No. 17), or which were very faint in it. Conversely, fraction 17 showed some not very strong lines which were absent in No. 31 and which were probably attributable to thulium. Apart from these lines the two spectra showed a great number of common lines of the same order of intensity. These lines are those which characterize the bulk of the original material, the impurities of which (thulium and the new element) accumulated, the former in the first and the latter in the last of my fractions.

Then I compared the spark spectra of my earths. The differences detected by this method of observation were much clearer than in the case of the arc spectra.

1. The lines in Table I. are the spark spectrum lines, attributable to thulium, which I detected in the fractions of low atomic weight (least soluble nitrates).

TABLE I.

2869.3	Faint.	3362.7	Fairly strong.
2899.9	Medium.	3425.7	"
2962.5	"	3441.6	"
3050.9	Faint.	3461.9	"
3131.4	Fairly strong.	3624.5	Faint.
3151.2	Medium.	3712.5	"
3173.0	"		

2. The lines in Table II. are the characteristic lines of the new element. They may very easily be detected in the fractions of high atomic weight (most soluble nitrates). They are either found exclusively in these fractions or else are much strengthened in them.

TABLE II.

*2701.8	Very strong.	3171.5	Fairly strong.
*2754.2	"	*3183.5	Medium.
*2798.3	"	3191.9	"
*2847.6	"	*3198.2	Strong.
2895.0	"	*3254.5	Very strong.
*2900.4	"	3275.5	Fairly strong.
*2911.5	"	*3312.4	Strong.
*2951.8	"	*3359.8	"
*2963.5	"	*3376.7	"
2970.0	"	*3385.6	Fairly strong.
*2989.4	Medium.	*3397.2	Very strong.
3020.7	Very strong.	*3472.6	"
*3056.8	"	*3506.8	"
3058.0	"	3554.6	"
*3077.7	"	3568.0	Strong.
*3080.3	Medium.	3624.1	"
3118.6	"	3647.9	"

The lines marked with an asterisk are the most characteristic of the arc spectrum.

For the limits between which my measurements extend these 34 lines constitute the relatively complete spark spectrum of the new element. (None of these lines is due to scandium, thorium, erbium, thulium, yttrium, or to any common element or rare earth, except the old ytterbium.)

I propose lutecium, Lu, derived from the old name of Paris, for the name of this element.

3. The other lines, included between the same limits, and enumerated in the spark spectrum of ytterbium, recently described by Sir W. Crookes, from one of my old preparations (loc. cit.), characterize the bulk of the old ytterbium. I propose to give this earth the name neo-ytterbium, Ny, in order to avoid confusion with Marignac's element.

4. The first spectrum of the old ytterbium was described by Lecoq de Boisbaudran (Comptes Rendus, 1879, lxxxviii., 1342), to whom Marignac had sent his new earth. It was a band spectrum. When I examined the chlorides of the extreme members of my fractionation by Lecoq de Boisbaudran's method, I noticed that in the earth of low atomic weight (neo-ytterbium) Lecoq de Boisbaudran's γ band was absent. On the other hand, in the earths of high atomic weight, which are very rich in lutecium, this band γ is more marked than the other bands of the spectrum.

The bands α (from $\lambda = 559$ to $\lambda = 552$) and β (from $\lambda = 576$ to $\lambda = 568.5$) are thus probably characteristic of neo-ytterbium, and the band γ (from $\lambda = 517.5$ to $\lambda = 513$) of lutecium.

To summarize the observations I have described here, Marignac's ytterbium is a mixture of two elements, neo-ytterbium and lutecium. The atomic weight of neo-ytterbium cannot differ much from 170, and the atomic weight of lutecium is not much above 174.

I may mention that Demarçay (Comptes Rendus, 1900, cxxxi., 387) denoted by θ an element characterized by lines 4008.2 and 3906.5. He regarded it as distinct from thulium, and included between erbium and ytterbium. I was not able to detect these lines, obtained by the use of a special coil, in either my spark spectra or in my arc spectra.

Moreover, Auer von Welsbach (Lieb. Ann., 1907, cccli., 464) has quite recently announced that by the fractionation of the double oxalate of ammonium and ytterbium he has detected spectral variations which he has not further defined. He did not give any measurements of the lines which he has observed between λ 7000 and λ 5000, and did not specify the elements which he supposes exist in the old ytterbium.—Comptes Rendus, 1907, cxlv., 759.

INDUSTRIAL ACCIDENTS AND DEPENDENCY.*

In the quarter ending March 31, 1907, according to statistics furnished by the Department of Commerce and Labor, 45,000 accidents were reported in this country, which number represents a totally inadequate idea of the great total. What compensation is afforded these sufferers and their families whereby the necessities of life may be acquired, not to mention that factor which enters into our lives, the payment of the doctors' bills? Prophylaxis and remedial legislation looking toward the diminution of accidents is one phase of the matter which cannot here be discussed. What are the conditions?

The lawyers of large corporations will tell us that the many suits brought for damages are mostly of the nature of blackmail, but the public at large do not believe it if jury awards are to be regarded as expressing the views of the masses; and physicians also know that this is far from being a proper statement of the case. An investigation of about 400 cases coming to the attention of the New York Charity Organization Society and reported by Francis H. McLean in a recent number of Charities and the Commons, December 7, 1907, affords an illuminating glance at what really happens in these cases.

About one-half of the accidents occurred to men under forty years of age, that is, in the best part of their industrial life. About 50 per cent happened to workmen in unskilled trades. This includes laborers, drivers, longshoremen, and others. Taking 241 of the scheduled cases where the wages were accurately determined, they find that forty-six, or 20 per cent, were earning from $5 to $10 a week only; and that 144, or about 60 per cent, were earning less than $15. The tables indicating occupations also show that this range of wages will run about the same in the cases where the weekly returns are not given.

The schedule of permanently injured reads as follows: Amputations of fingers or toes, seven; amputation of legs, feet, hands, or arms, twenty; brain permanently injured, ten; partially crippled, eight; paralyzed, five; blinded, fifty-three; permanently injured by blood poisoning, two; spine injured, two; internal injuries, three; loss of hearing, one; made deaf and dumb, one; hernia, resulting in partial loss of wage earning ability, at least 250; rendered insane, twenty-one; killed, forty-five.

Coming to the question of donations or settlements by employers, the author limits himself to an analysis of about two hundred cases, in which the returns were fairly complete. Of these, some sort of donation or settlement was made in forty-seven, so far as known. Absolute accuracy is not alleged for these figures, but approximation to the total truth. This is about 20 per cent of the total. This table of forty-seven settlements and donations is a veritable crazy quilt of absurdities when viewed comparatively. For temporary injuries the settlements are generally quite fair. That is, full wages were paid during the period of disability in a number of cases. When more serious results were present, many incongruities were to be observed. The facts regarding litigation, as nearly as they could be obtained, are given. Only the 223 cases which are fairly well scheduled in this regard are taken. The figures given are mutually exclusive—suit begun, nineteen; suit begun, but settlement expected, three; suit begun, with no probable hope of recovery, two; suit begun, but complicated by absolute release, two; suit begun and lost, four; judgment obtained in two cases, one for $300 and the other for $200. The $300 one is appealed, and in the other the lawyer took half for his fee.

With reference to settlements, it should not be forgotten that many elements enter into the individual settlements as they are now made—the question of liability, how much the sufferer was himself to blame, how much the other employees were responsible, and the size of the company and its ability to make generous settlements. These and many personal elements enter in. The net result, however, is one which is disgraceful for a civilized community.

In forty-nine cases where the families were provided with charitable assistance there was a stated expenditure of charitable relief of $2,646. In many cases, however, such general entries as "rent paid by society" or "church," etc., appear. It is, therefore, a conservative estimate to figure $50 as an average expenditure in the ninety-two families which were in care of New York charitable societies. In addition, it must be remembered that there were 111 persons who were given hospital care for periods varying from a month to a year; also there must be reckoned the cost to various charitable agencies, public and private, in care of the fifty-three blind. To this must be added the cost of the twenty insane inmates of the State hospitals, also the cost of medical attention in the hernia cases, in many of which the sufferers were provided with free trusses, etc. What the total figures would be involves so much estimating that the committee in this statement of facts does not wish to make the venture. It believes that the amount of money thus expended in relief, through public and private sources, during one year would amount to a good round sum.

But this is not all. In ninety-two cases which were closely under the observation of trained charity agents special pains were taken to have them make returns

* Abstracted from the New York Medical Journal.

upon the marked deterioration of the families themselves resulting from the accidents and the conditions which followed. Such deterioration was decided in at least twenty-six of the ninety-two. The forms of deterioration may be thus summarized: Chronic dependency; intemperance, not before present; lowering of standards of living; breaking down in health of widow; family broken up; habit of begging developed; savings used up; furniture pawned; first experience of being dispossessed. When it is remembered that these ninety-two cases include only a small fraction of the cases of permanent disability investigated, the amount of temporary and permanent deterioration becomes a social debt of great magnitude. What that social debt is, if one were able to-day to know accurately the results of the thousands of accidents which have occurred within the last few years, is the unanswered question.

THE ANILINE DYE INDUSTRY.

HOW IT BEGAN AND HOW IT HAS DEVELOPED.

In 1856 William Henry Perkin, then a young man of eighteen, was working in London as the private assistant of Prof. A. W. Hoffmann. He was not satisfied, however, merely to spend the day on Hoffmann's researches, and he fitted up a rough laboratory in his father's house where he could work in the evenings and in vacation time. Here, with a purely scientific interest, he tried some experiments which he hoped might lead to a synthesis of quinine. He got, instead, a dirty brown precipitate which must have seemed very unpromising. He became interested in it, however, and repeated the experiment with aniline. This gave him a black and still more unpromising product, but on examining it further he found in it a beautiful purple coloring matter which proved to be what we now know as the "mauve dye." At that time, only fifty years ago, such a thing as an artificial dye was unknown, and we must marvel at the wonderful insight and energy of this boy who grasped the significance of his discovery and made it the beginning of the great industry of coal-tar dyes. After further study of the new compound and after practical tests in the dyeing of silk he gave up his position as Hoffmann's assistant and began the manufacture of the new dye. He was fortunate in having a father who had enough faith in the undertaking to risk almost his whole fortune on the venture, for it would have been hardly possible, then, to secure from outsiders enough capital for so hazardous an enterprise.

At that time, benzene, the raw material for the manufacture, was not to be had in the market, of definite quality, and its distillation from tar had to be developed. Further, after the dye had been prepared it was quite different from the dyes then in use, and methods for its application to silks and other goods had to be worked out. All these difficulties were finally overcome and within two years the mauve was supplied for the dyeing of silk. As soon as success was assured, others turned their attention in the new direction. Three years later magenta was discovered in France and soon after other dyes were prepared by Perkin, by Hoffmann, and others. Hoffmann's discoveries of dyes are especially interesting because he thought that Perkin was making a mistake when he left him. And Perkin himself was much afraid that by entering a technical pursuit he would be prevented from following the research work in which he was so much interested. He determined, however, that he would not be drawn away from research, and in that determination and its imitation by others I think we may see the secret of much of the success of this industry. In no other industry are so many highly-trained chemists employed and in no other is the work so closely related to research in the pure science.

Twelve years after the discovery of mauve, Graebe and Liebermann succeeded in preparing alizarin, or turkey red, from the anthracene of coal tar. This discovery, again, was the result of pure scientific work undertaken without reference to its technical importance. The first method of preparation, too, was by a difficult process which was too expensive to be commercially feasible. As soon as the scientific problem had been solved, however, the question was taken up from the commercial standpoint and Perkin soon found an economical method for the manufacture of the dye. At that time large quantities of madder root were raised in Holland and elsewhere for the preparation of alizarin. It was soon found that the dye could be made much more cheaply from anthracene and within a few years the artificial alizarin drove the natural product from the market and the Dutch farmers were compelled to raise other agricultural products. So important is this dye that the value of the amount manufactured in 1880 is given as $8,000,000. It is estimated that it would have cost $28,000,000 to manufacture the same amount of the dye from madder root. This means that the world saves $20,000,000 a year in the manufacture of this single dye, an amount that would pay for the maintenance of a good number of chemical laboratories.

The development of this manufacture was so rapid that by 1873 Perkin and his brother found that it would be necessary to double or treble their factory to supply the demand. Perkin was then only thirty-five years of age and his love of research had survived his seventeen years of experience as a manufacturer. Partly for this reason, partly because he did not wish to assume the responsibility of the larger factory, he sold the works and after that time he devoted himself to scientific research, with distinguished success. The jubilee of the discovery of mauve and the founding of the coal-tar industry was justly celebrated last year as one of the great events of the century, but Perkin's scientific aschievements and the way in which he stood for high ideals in research are, I think, of even greater value to the world.

The manufacture of mauve was quickly successful and after the scientific discovery of the structure of alizarin, commercial production soon followed. With indigo, the case has been somewhat different. The scientific problem was in itself more difficult and the course of events has illustrated with especial clearness the difference between the scientific and the technical solution of the same problem. Baeyer began his work on indigo in 1865. During the five years following he prepared a number of important derivatives, which contributed much toward the clearing up of the relation between indigo and other compounds. In 1870, he found that some of the work he was doing seemed to cover much the same ground as some work which Kekulé had undertaken, and out of scientific courtesy he allowed the matter to lie dormant for eight years. In 1878, as Kekulé had published nothing further of importance, Baeyer returned to the problem and in 1880 he obtained a successful synthesis of indigo. With the brilliant success of alizarin in mind patents were taken out, and it was generally expected that the manufacture of the artificial dye would soon become of commercial importance. But these hopes of immediate success were not realized. Two principal difficulties were encountered. The original methods of synthesis involved a considerable number of difficult transformations between the raw material, toluene, and the finished dye, indigo. These transformations required a very large amount of careful scientific study before the conditions could be found under which they could be carried out in ways that would be economical of time and material. But when this side of the problem had received a partial solution as the result of fifteen years or more of work, a second difficulty presented itself in the magnitude of the interests involved. It is estimated that the world uses about 5,000 tons of indigo in a year. Now, even with the perfected methods it takes about four pounds of toluene to make one pound of indigo and the present production of toluene is only about 5,000 tons a year. The whole of the toluene produced would give only about one-fourth of the amount required to supply the world's demand for indigo. Furthermore, the toluene now produced finds a ready market for use in the preparation of other dyes and other compounds. Any attempt to use a considerable amount of toluene for the manufacture of indigo would be met, therefore, by a rising price which would quickly make the production by this method commercially impossible.

Fortunately, another synthesis of indigo was discovered by Heumann in 1890 which made it possible to prepare indigo with the use of naphthalin as a raw material. As the supply of naphthalin is ample for the purpose, the second difficulty was overcome. But the new process required the solution of a whole set of new problems and it was not till seven years later that the Badische Anilin- und Soda-Fabrik considered that the process was sufficiently well developed to justify preparation for the manufacture on a large scale. So carefully had they worked out every detail, however, that during the three years that followed they were willing to expend four and a half million dollars in building the factory and apparatus for this one enterprise. As the world uses in a year twelve to fifteen million dollars' worth of indigo, the manufacture on a large scale is justified, and there is every indication at present that the artificial indigo is slowly displacing the natural product. The farmers in India are already feeling this new competition and it is doubtless only a question of a few years before they will be compelled to devote their attention to other crops. The hope has been expressed that the land released in this way may be used for raising food products, which may give some relief from the famines so common in that country.—William A. Noyes, extract from inaugural address at University of Illinois.

DETECTION OF CANE SUGAR IN PLANTS BY MEANS OF INVERTIN.

Invertin possesses, as is well known, the property of hydrolyzing cane sugar; in addition to cane sugar, gentianose, raffinose, stachyose, and certain other polysaccharides which have up to the present escaped isolation are also hydrolyzed by invertin. These substances, which may be regarded as polysaccharides, consisting of a molecule of cane sugar combined with one or more molecules of a hexose, may be excluded by the optical examination of the liquid before and after inversion by invertin. The invertin for this purpose can be prepared by mixing fresh baker's yeast previously washed with sterilized water with eight to ten times its weight of 95 per cent alcohol, allowing the mixture to stand twelve or fifteen hours, filtering with the aid of the filter pump, washing the residue first with alcohol and then with ether, and finally drying at 30 deg. to 35 deg. C. The dry product if kept free from moisture in a well-closed bottle will retain its activity for a long time. For use 1 gramme is mixed with 100 cubic centimeters of water, saturated with thymol, and filtered; the filtrate will remain active for a week. Cane sugar is detected as follows: About 250 grammes of the material is introduced in portions into boiling 90 to 95 per cent alcohol, care being taken that the boiling is not interrupted. The boiling is continued for twenty minutes, and the liquid then cooled and filtered. To this a slight excess of calcium carbonate is added, the alcohol distilled off, and the residue dissolved in thymol water so that 250 cubic centimeters is produced. This is then divided into two portions, A of 50 cubic centimeters, and B of 200 cubic centimeters. To B 1 gramme of the prepared yeast is added, and the mixture kept at 25 to 30 deg. C. for two days. From each flask 20 cubic centimeters is taken, decolorized with 4 cubic centimeters of solution of lead subacetate, and polarized in a 2-decimeter tube. If cane sugar be present it will be hydrolyzed in B, and the polariscope will indicate that a lævo-rotatory substance has been produced. The reducing sugar in both flasks is then determined in the usual way; the difference, due to the invert sugar produced in B, is calculated to cane sugar; the lævo-rotation produced by the hydrolysis of this amount of cane sugar is calculated, and should be identical with the difference found. The presence of cane sugar has thus been proved in the reserve organs of sixty-four species of plants and in the leaves of forty-four species, and justifies the conclusion that it is always present and necessary. Cane sugar, therefore, appears to be a constant and necessary constituent in the metabolism of plants.—E. Bourquelot, Archiv. d. Pharm.

SULPHUROUS ACID AND THE SULPHITES AS FOOD PRESERVATIVES.

The chief of the Bureau of Chemistry of the Department of Agriculture, Dr. H. W. Wiley, has recently issued a report of nearly 300 octavo pages giving an account of his experiments with sulphurous acid and the sulphites used for food preservatives as regards their effects upon the human system. In this investigation Dr. Wiley has had the assistance of Mr. W. D. Bigelow, Mr. F. C. Weber, and others. The experiments were performed upon young men who volunteered for the purpose. The sulphurous acid was administered in the form of the gas dissolved in water, and the sulphites were given in capsules. This inquiry is thought to be perhaps of even greater importance than the previous studies of the effects of boron compounds and of salicylic acid and its salts, on account of the more extensive use now made of the sulphurous substances as preservatives of food products.

The unequivocal conclusion is arrived at that sulphurous acid and the sulphites, which have no nutrient value in themselves, exert a distinct deleterious influence when taken in considerable quantities and for more than a very short time. Dr. Wiley's cautious temperament would naturally compel him to stop short of the infliction of permanent disease, but enough seems to have been ascertained to prove the danger of resorting to sulphurous acid and the sulphites as pre-

servatives of food preparations, and to indicate that even the fumigation of wine casks with sulphur may lead to a dangerous contamination of the wine contained in them, which is said to absorb no slight amount of the sulphurous acid which is generated.

It really seems as if only the old household preservatives were safe, such as salt, sugar, vinegar, brandy, spices, and smoke, and perhaps some of them should be used less freely than they are at present. Recent national legislation on the subject has come none too soon, and it ought to be supplemented by State enactments.—New York Medical Journal.

MAKE-BELIEVE FLOWERS.*

A CASE OF ADAPTATION TO EXISTING CONDITIONS.

BY S. LEONARD BASTIN.

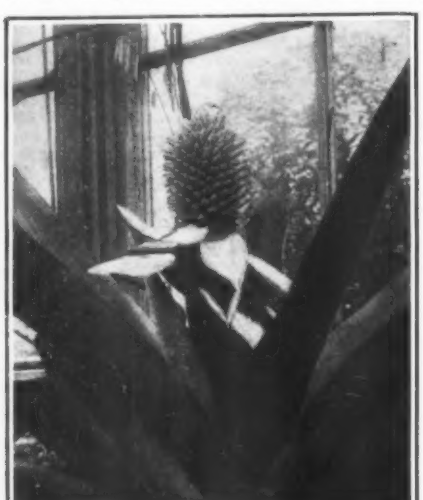
COMPETITION in the natural world is so keen that those individuals which can not at least come up to a certain standard must soon be outstripped by others in the great struggle. As a consequence it is of the

SALVIA HORMINUM RUBRUM.

Southern Europe. A flower which advertises itself by its variegated foliage.

utmost importance that species which find themselves at a disadvantage in any way should summon all their resources together to strengthen their position. To this end we may attribute many of the remarkable developments both in the animal and vegetable kingdoms.

Among plants several of the most interesting examples of this particular form of evolution are to be seen in the case of species which have adopted unusual methods for the advertisement of their flowers. As every one knows, a number of species are wholly or partially dependent upon the visits of insects for the fertilization of their blooms. In order to make the presence of the flowers known, these plants have resorted to the practice of surrounding the essential



AECHMEA OF BRAZIL.

The leaflets surrounding the flower are bright pink, although the actual flowers are not in the least attractive.

organs with gaily colored corollas. For some reason which it is not very easy to understand, a large group of plants representing widely diverse genera have been unable to produce attractive blossoms; yet it is necessary that these flowers should be cross-fertilized by insect visitation. Nothing daunted, these enterprising species make up their deficiencies to such good purpose that quite often they end in outstripping their more fortunate rivals.

An excellent instance of a species which has resorted to rather unusual methods of drawing attention to its flowers is *Poinsettia pulcherrima*. This plant, not unfrequently cultivated under glass on account of its decorative qualities, is a native of Brazil, and a member of the great *Euphorbia* family whose representatives range almost all over the world. The *Poinsettia* with its small cluster of greenish flowers would be scarcely noticeable among the mass of greenery surrounding the plant in its tropical home; but the species is well able to take care of its own affairs, for it has converted the terminal leaves of the blooming shoot into brightly colored bracts, so that each group of flowers is surrounded by rays of the most vivid crimson imaginable. An interesting side light as to the origin of the bracts is seen in the fact that at times the upper leaves are partly green and partly red. Another genus of South American plants—Bougainvillea—has found it desirable to adopt a special mode of advertising its flowers, although these are provided with a proper corolla, and are almost as attractive as some of the smaller species of *Primula* for instance. But they are a dull yellow color and

BOUGAINVILLEA GLABRA.

would be likely to appear insignificant among the leaves of the plant itself were they not surrounded by three large bracts colored in a very striking shade of lilac. Bougainvilleas are climbing plants, and as the flowers and their showy appendages are produced in great masses, the presence of the floral organs is announced in a most striking fashion to all passers by. Indeed a Bougainvillea in full bloom would be seen from a great distance, and one could conceive the insects being attracted from all parts.

Of course in composite flowers, the most showy portions of the blooms really serve no other purpose than to advertise the real essential organs. Daisies, chrysanthemums, and asters are typical of this special formation, when in their single state. If we take a specimen of any of these flowers we shall find that the outside circle of colored rays is composed of nothing more than petal-like processes. They are perfectly sterile; in fact their sole office in life is to look attractive. The central mass of yellow material is composed of hundreds of flowers, destitute of petals but all provided with the organs of reproduction. By this clever arrangement the composite flowers are able to produce a far greater number of seeds than is the case in the majority of orders.

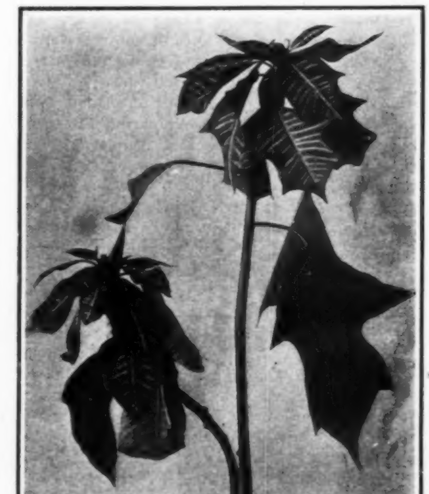
In a Southern European salvia (*S. horminum rubrum*) is to be seen yet another mode of drawing attention to somewhat unattractive flowers. This plant has rather small blooms in the regular labiate style, sprouting out from the axils of the leaves. With about two-thirds of the shoot the foliage is of an ordinary green color, but in the remaining terminal portion the leaves are first of all partly and then finally wholly colored in bright pink. Thus during the blooming season this decidedly humble plant is transformed

PIERIS JAPONICA.

The terminal shoots of this plant are bright scarlet when the flowering season is on.

into a most striking object, so much so that it is recognized as a valuable border plant in the garden. It is notable that as the plant passes from its blooming stage the pink gradually becomes green, proving that they are actually leaves which have taken upon themselves the rather unusual office of helping the flowers to make known their presence.

As all botanists are aware, red is frequently associated with growing shoots. It is interesting to observe that this point has been turned to good account in the case of a Japanese indigenous species called *Pieris Japonica*. The plant is shrubby in habit, and is nearly allied to Arbutus. In the spring the Pieris produces its small white flowers, which are often so sheltered by the leaves as to pass almost unobserved.



POINSETTIA PULCHERRIMA.

A flower inconspicuous because of its greenish petals, but attractive to cross fertilizing insects because of its bright terminal leaves.

But notice what takes place at this season. A little bit ahead of the opening of the blooms the fresh growth commences from the shoots, and the young leaves are of a most brilliant scarlet. Passing insects cannot fail to mark the bright display, and, alighting, become aware of the slightly fragrant flowers.

* From American Homes and Gardens. Published by Munn & Co.

It would seem that one will not be very wrong in supposing that strongly marked leaf coloration is generally present to make the plant conspicuous. Such genera as Coleus, Codiæum, to mention only two, often display the most gorgeously colored foliage although their flowers are comparatively insignificant. A species of Aechmea has been found in Brazil in which the leaflets surrounding the flower stem are tinted with bright pink although the actual flowers are not at all attractive.

Many observers have proved up to the hilt that insects exhibit a strong tendency to settle on a colored object, and it can be imagined that if the specimens could once be induced to alight on the leaves they would be almost certain to come across the flowers. It is very remarkable in this connection that many of these species with showy foliage assume their brightest colors just about the blooming time of the plant.

In dwelling upon a question such as the one under consideration it is always a strange reflection, as to why it is that certain species seem to be more favored than others. To particularize in an instance, one may take the case of the salvia referred to above. This plant has numerous allies, some of which are scarcely so well favored in the attractiveness of their flowers as *S. horminum rubrum*. Yet these have not been able to blaze forth to the world with all the glory of gaily colored leaves and have to be content with ordinary green foliage. The problem is deep and far reaching, and one which it is far more easy to propound than to explain. It seems to be only half an explanation to say that one plant requires special assistance, and the other does not. Probably the question could not be settled in one answer for it is likely that the reason is very different in individual cases.

THE FISHES OF THE DEEP SEA.

STRANGE LIFE FORMS NEAR THE OCEAN'S BOTTOM.

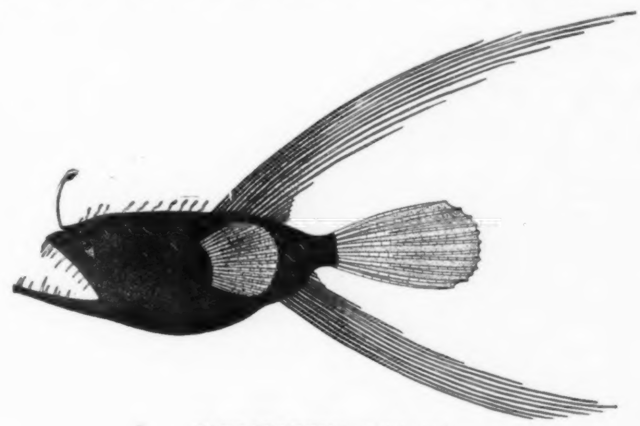
BY DAVID STARR JORDAN, LL.D., PRESIDENT OF STANFORD, JR., UNIVERSITY.

THE study of the animal life of the deep sea is mainly concerned with three categories of creatures. The first of these is that named by Haeckel, *Plankton*—the organisms, mostly minute, which float on the surface of the open ocean. Among the Plankton, young fishes may sometimes be found, occasionally the young of shore fishes, carried from their natural habitat by oceanic currents. Next come the pelagic forms, those moving freely in the water near the surface, and choosing the open sea by preference. Besides whales and dolphins, many fishes are pelagic. Among these are various large forms, sharks and numerous members of the mackerel family, as the tunny, the albecore, the bonito, and their relatives. The smaller pelagic fishes usually go in schools, the larger ones swim about singly. Among those in schools are certain species of mackerel and most of the flying fishes. All these pelagic forms resort to certain regions, chosen bays and straits, usually within the tropics, for purposes of spawning. From these regions they sally forth on more or less definite predatory expeditions. Many pelagic fishes breed in the Mediterranean, and in the West Indies. Others find their homes about the Santa Barbara Islands of Southern California, and in Hawaii and Southern Japan.

The third category of deep-sea life is that constituting the bassalian fauna or life of the depths. This includes forms living below a depth of 500 feet, some of them swimming freely, others lying close to the bottom, or, in the case of invertebrates, often attached to the ground. The bassalian fauna grades perfectly into the ordinary shore fauna, yet it has many characteristics of its own. It is largely composed of fishes, yet sea urchins, shrimps, crabs, crinoids, and a great number of microscopic forms extend into its region and form part of it.

In general, the bassalian area lies below the region penetrated by sunlight. The differences of temperature of day and night, of summer and winter, do not extend to it. It is, therefore, an area of cold and darkness, of uniformity of conditions, and the tremendous pressure of the water keeps the creatures developed in it from extending their range upward or downward in the water. A deep sea fish rising above its depth is crushed by the reduction of the outside pressure. Its tissues swell, its blood vessels burst, its eyes are forced out, its stomach turned wrong side out as the pressure within exceeds that on the outside. Conversely, a fish sinking below the pressure to which it is accustomed is soon crushed or suffocated. Sometimes a deep sea fish, in a struggle with its prey, is carried above or below its depth, in which case both are destroyed. It will be understood that the tissues of a fish developed below a mile of water are permeated with water of the same degree of pressure as that outside. The deep sea fish, in his normal position, no more feels the 2,312 pounds pressure per square inch of a mile depth of water than we feel the 15 pounds per square inch of forty miles depth of atmosphere.

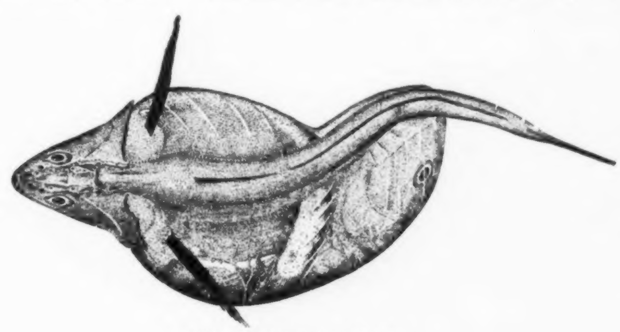
The greatest depth of the sea yet recorded is approximately six miles. This is found to the east ward of Guam, in the mid-Pacific. Being in the mid-Pacific myself at the time of writing these words, I cannot give the exact figures. At this depth life was



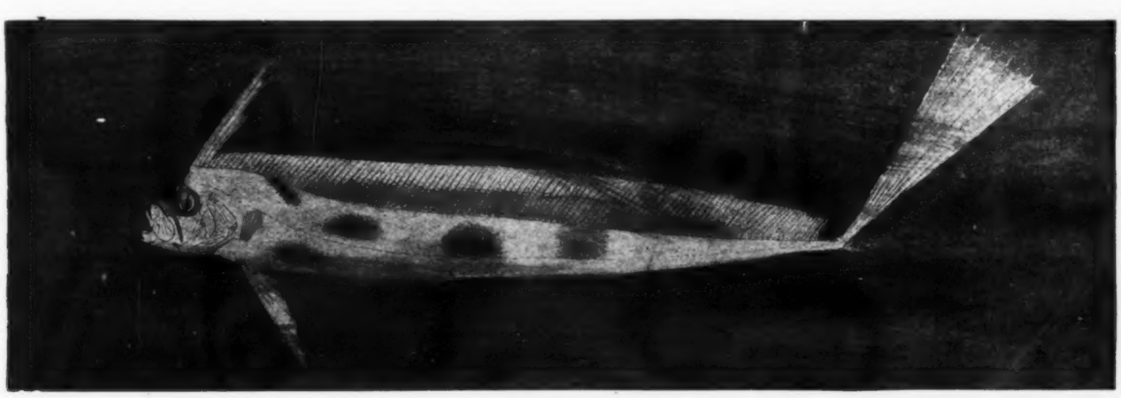
CAULOPHRYNE JORDANI.

STOMIAS FEROX.

NOTACANTHUS PHASGONORUS.



CHIASMODON NIGER.



DEALFISH, OR KING OF THE SALMON.

Trachypterus rex-salmonorum. Jordan & Gilbert. Family *Trachypteridae.* From a specimen taken off the Farallones.

found, but no fishes were obtained. The greatest depth at which fishes have been taken is under the Gulf Stream, off the Carolina coast, the depth approaching five miles, as I remember.

The study of the life of the deep sea has been mainly the result of vessels especially fitted for the work of dredging and trawling. First in importance in this regard stands the "Albatross," a vessel of the United States navy, controlled by the United States Bureau of Fisheries. Next comes the British ship "Challenger," which made a notable cruise around the world for the purpose of deep sea investigations. This trip has yielded larger results than any other single cruise, so far as the deep seas are concerned, but the "Albatross" has made a far greater number of expeditions. Other notable dredging vessels are the "Investigator," in the Indian Ocean; the "Travailleur," and the "Talisman," about the coast of France; the "Vigilante," in the Mediterranean; the "Knight Errant," about Great Britain; the "Blake," and the "Fish Hawk," in the United States, and the "Thetis," in Australia.

The writer's experiences on the deep seas have been mainly on the "Albatross." The principal piece of apparatus used in this work is the beam trawl. This is a long net resting at its mouth on two curved iron bars like sled runners.

The method of fishing is to drop this net, properly weighted and adjusted, to the bottom of the sea, holding it by a wire cable. When it has reached the bottom, whatever the depth, the vessel steams slowly forward, dragging it for a distance; it may be for a few rods, it may be half a mile. Then by means of a steam windlass the net is drawn to the surface. Those fishes which lie near the bottom are sure to be taken, and others may be caught as the net rises. As nets are unknown to these creatures, they make no effort to escape, and even the most active are readily caught if near enough to the bottom.

Sometimes the trawl is caught on a rock and is lost altogether. Sometimes the net is torn on a coral mass or other jagged obstruction. Sometimes it is filled with soft mud, or with loose stones; sometimes again with sea weeds, or occasionally, when the depth is not great, with sea urchins, or sponges, or scallops, or other shellfish. Sometimes it contains nothing at all, even after a laborious half-day has been given to a single operation. More often the naturalist is rewarded by a few fishes, with crabs, sponges, sea urchins, and sometimes in a single haul he captures very many.

At the depth of a few hundred feet the fishes are usually red in color, with very large eyes. At greater depths they are all of a uniform violet or inky black, and the eyes are either excessively large or excessively small. The very large eyes seem to represent an effort to make the most of what little light there is. The very small ones are simply vestiges, and mean that nature has given up the idea of letting her creatures see. A certain number of these deep-sea fishes are provided with lanterns or luminous spots by which they find their way in the great depths. All the species thus provided have well-developed eyes. The luminous spots usually lie in rows along the side of the body. In some forms the whole snout is luminous, like the headlight of an engine. In the case of a Japanese deep-sea sharklet the whole belly is luminous. Of this species, *Etmopterus lucifer*, Dr. Peter Schmidt, of St. Petersburg, once made a sketch in the night by the light given out of the animal itself. This little illuminated shark is only about one foot in length.

The deep-sea fishes are all descended by degeneration and specialization from various tribes of shore fishes. The degeneration involves loss of organs, the softening of the tissues, both bones and muscles, and often the loss of fins or scales. By the stretching of the tissues a deep-sea fish may often swallow another of considerably larger size. The specialization consists in the great development of luminous spots in many cases, the development of very long teeth in most cases, and in occasional modifications of fins as organs of touch.

Most of the luminous forms are of the group called lantern fishes, degenerated from allies of the smelt and trout. Many deep-sea forms are modified eels. Still others are derived from the anglers or fishing frogs. Some are degenerate herrings, some degraded mackerels, and the large group called grenadiers are modifications of codfish. A few sharks and chimæras enter the depths, as also occasional members of several others of the various orders and families of fishes.

As the conditions of life in the depths are very uniform, there is practically no difference between the deep-sea fishes of the tropics and those of the North. Many species extend their range unchanged over a very wide area, and yet species are separated from their allies by isolation in the deep seas as elsewhere. Most of the species of the Atlantic are different from those of the Pacific. Those about Hawaii are different from those of Japan for the most part, and those of California and Alaska are still more different.

Among the deep-sea fishes are many most astonishing forms. Perhaps as striking as any is the great oar fish, *Regalecus*, called in Europe in different languages, "King of the Herrings," and in Japan the "Cock of the Submarine Castle." This fish has the shape of a broad ribbon, sometimes twenty-five feet long, nearly a foot across, and about two inches in thickness. Its texture is soft, almost gelatine-like. Its color is transparent blue, and on its head the dorsal spines rise high, like a mane, each with a crimson knob at the tip. This creature lives in the open sea, at no very great depth, and occasionally it is cast on shore, where it is always reported as a sea serpent.

To the books on the deep-sea fishes the reader is referred for the details in these matters.

To the practical question as to the value of these fishes we may say: Most of them are good to eat, but their flesh is watery and without flavor. Their value to museums far exceeds their value for the table, and their value to man is chiefly the intellectual one of showing him to what lengths nature can go in the direction of utilization of space and adaptation of forms. And the thousand illustrations of the biological principles of evolution which the deep-sea fishes give are worth more to man, in his intellectual and moral development, and finally in the conduct of life, than would be any conceivable number of fish dinners.

Wherefore the bassalians have their place in the cosmos as clearly as the cod or the herring.—The Independent.

HOW QUARTZ CRYSTALS FORM.

THEIR PHYSICAL NATURE AND CHEMISTRY.

BY EDGAR T. WHERRY.

CRYSTALLIZED quartz, though one of the most widespread and abundant of minerals, is much sought after by collectors on account of the many varied and beautiful forms which it presents. After a little practical experience in the field it becomes an easy matter to recognize, by the character of the adjacent soil or rock, the points where quartz crystals are likely to be found. Yet the ideas of most mineralogists concerning the origin and manner of development of these crystals are very vague and indefinite. The present paper is offered in the hope of clearing up some of this uncertainty, and consists of a brief abstract of the conclusions obtained in the scientific study of the matter.

The element silicon is second in order of abundance at the surface of the earth, forming 28 per cent of the known crust. In the natural system of the chemical elements it lies in the carbon group—the group in which the normal oxides are dioxides, which includes also titanium, tin, and lead, together with the rarer germanium, zirconium, cerium, and thorium.

In nature silicon never occurs free, but almost entirely as the dioxide, either alone, in the form of quartz, tridymite, and certain doubtful species, or combined with bases in the numerous silicates. Of these, quartz alone is selected as the worthy object of the present paper.

Quartz crystallizes in the trapezohedral group of the trigonal system. The faces it most commonly shows are the positive unit rhombohedron *r*, the negative unit rhombohedron *z*, and the first order prism *m*. Besides these the following appear quite frequently: The trigonal pyramids *s*, the trapezohedron *x*, and the steep rhombohedrons *l* and *M*. But the remainder of the host of "rare planes" are so seldom developed that they may be left out of consideration.

Before taking up the principal theme of discussion, there is still another subject which should be briefly alluded to—that is, the color. In its pure state silicon dioxide is, of course, quite colorless, and the clear "rock crystal" is by far the most abundant of its varieties. Crystals showing green, smoky, and amethyst tints are, however, by no means uncommon.

The green color is unquestionably due to the presence of chlorite inclusions. The smoky effect is, in most cases, produced by carbonaceous matter, for, on heating, the color disappears with evolution of a strong "burnt" smell. Amethyst, I must confess, is somewhat of a puzzle. The common presence of rutile, taken in connection with the existence of deep purple compounds of titanium, is certainly very suggestive. But recent work on metallic colloids and ultra-microscopic particles has tended to emphasize the importance of such substances as the causes of problematic mineral colors. The amethystine tint in the quartz may be due to "colloidal" particles of rutile in one case, and iron oxide in another, in specimens in which inclusion of larger masses of the corresponding substances are visible.

Returning now to the principal subject—the mineral quartz occurs in a great variety of associations. It is a constituent of almost every rock, forming the mass of the sandstones and appearing in greater or less quantity in many others. In the majority of cases it is, of course, massive, and really good crystals are found only in the veins and cavities.

Upon considering the origin of these formations, the first question which naturally arises is, have the minerals crystallized from water solution or from igneous fusion? The answer is unmistakable; it is to be read in every feature of the deposits. The presence of calcite, zeolites, and other minerals, which are destroyed by even moderately high temperatures; the existence of coloring matters, which disappear on gentle heating, in the quartz crystals themselves; the occurrence of corrosion figures; all agree in indicating that the crystallization occurred at a low temperature and from water solution.

Now where did the silica come from and why did it crystallize? Let us first consider its source. The rocks exposed at the surface of the earth are, as is well known, continually undergoing alteration, or, as we commonly say, are weathering. Besides mechanical disintegration, a chemical change is taking place, consisting in the dissolving out of certain constituents. It is a matter of common observation that the feldspars pass into clay, or kaolinize. This comparatively simple case may be taken as the type of the alteration of all the other minerals. Expressed in chemical symbols it runs as follows:

$$2KAlSi_3O_8+2H_2O+CO_2=H_4Al_2Si_2O_9+K_2CO_3+4SiO_2.$$

Or, in words, orthoclase, when acted upon by water and carbon dioxide, yields kaolin, potassium carbonate, and free silica.

The carbon dioxide comes in part from the atmosphere and in part from decaying organic matter. It enters into the reaction in solution in rain water. Of the products, the kaolin is completely insoluble and remains behind as clay; the potassium carbonate dissolves in the water, and the silicon dioxide, being liberated in the colloidal form, also passes largely into solution. (A colloid, it will be remembered, is a substance which apparently dissolves in water, but which is really in a state of very fine suspension, and may be removed by dialysis—filtering through animal membranes.)

Now this change does not occur only at the surface, although, to be sure, it is most active there. Under normal conditions it may take place at depths of several hundred feet, and in exceptional cases, as much as half a mile down into the rocks. Accordingly, as the water gradually descends, it takes up more and more colloidal silica, and before long it becomes entirely saturated with this substance.

Before considering the actual formation of the quartz crystals, let us briefly review the course of the process of crystallization in general. When a liquid has dissolved all of a given solid that it can hold, it is said to be saturated. If such a solution is kept under constant conditions of temperature, pressure, amount of liquid, and amount of foreign matter present, it will neither take up nor deposit any of the solid. But let one of these conditions be changed, and the solution will become either unsaturated and tend to dissolve more solid, or supersaturated, so that the dissolved solid will tend to separate.

Alum and common salt may be used in illustration of these principles. Some water is heated to boiling and powdered alum introduced until some of it remains on the bottom permanently. The solution is then saturated with alum at 100 degrees, the temperature of boiling water. If a portion is poured off from the undissolved material and allowed to cool, it becomes supersaturated, owing to the decrease in temperature, and after standing a short time will deposit

the well-known octahedral crystals of alum. The effect of change of pressure upon such a saturated solution would be difficult to show as a lecture experiment, so it will be sufficient to note that for most substances a decrease in pressure acts like a decrease in temperature, and causes separation of crystals.

By leaving the cold saturated solution of alum exposed to the air for some time, the crystals on the bottom of the dish will grow larger. That this is due to evaporation of the liquid is well known and needs no further comment. To illustrate the fourth method of altering the saturation of a liquid, some hydrochloric acid is added to a saturated solution of common salt, and a considerable amount of the latter promptly separates in solid form.

There is still one property of saturated solutions which calls for further discussion. In general, if water is saturated with a salt at 100 degrees and allowed to cool to room temperature in a closed vessel, no crystals will separate, even though the liquid be highly supersaturated. But let the minutest crystalline particle of the compound present be introduced, and crystallization will immediately occur.

This may be well illustrated by sodium thiosulphate. The commercial crystallized salt, the "hypo" of the photographers, is gently heated with half its weight of water, and dissolves, forming a slightly turbid liquid of oily consistency. When every particle of the solid substance has disappeared, the vessel is covered and permitted to cool, undisturbed. A glass rod to which a minute fragment of the crystallized salt has been attached is now introduced, and soon becomes covered with a mass of radiating crystals. And when some of the solid is agitated near to the open vessel, so that particles of its dust fall in, the liquid will suddenly return into a solid crystalline mass.

Now let us return to the real subject of discussion, the development of quartz crystals. It will be remembered that in our consideration of what takes place at the surface of the earth, we were watching the progress of rain water through the weathering rocks; and we saw this water become saturated with colloidal silica.

This colloidal silica solution is very sensitive to change of conditions, and, in obedience to the principles already explained, readily becomes supersaturated and tends to deposit a part of its solid matter. One result is the separation of what is known to mineralogists as opal variety hyalite, which is frequently found lining fissures through which water has been descending. At first sight it would seem as if there should be no limit to the depth at which this hyalite may form. But there is one very important factor whose influence must not be overlooked—that is, the pressure. As is well known, the pressure increases rapidly as we descend below the surface of the earth, owing to the weight of the overlying column of water. Now it has been found by experiment that increase in pressure greatly increases the solubility of colloidal silica in water; and it follows directly that the tendency for the opal to separate from the solution becomes less and less as we go farther down. Here, however, another property of colloidal silica comes into play—its instability.

Like many other similar substances, the colloidal form of silicon dioxide possesses, especially at rather elevated temperatures, a strong tendency to revert to the crystalloidal form. This latter being extremely insoluble in water, separates out, as from a highly supersaturated solution, as fast as it is produced; and we call the resulting substance crystallized quartz.

To recapitulate, the conditions necessary for the formation of crystallized quartz are: first, water saturated with colloidal silica derived from the belt of weathering rocks; second, a fairly high pressure to keep the colloidal silica as such in solution; and, finally, a moderately high temperature to promote the change of the colloid silica into the crystalloid form.

Our story, however, does not end here. There still remains to be considered the cause of the great variety of forms in which the mineral quartz appears. The alteration of sandstone into quartzite is a typical illustration of the actual process of crystal formation. Common beach sand, as is well known, is composed essentially of minute grains of pure quartz, more or less rounded by the wave action to which they have been subjected. When our solution passes through this material, the grains form ideal nuclei around which crystallization may take place. Every grain of sand will accordingly grow into a crystal, and the loose formation becomes first a sandstone, and then, when the enlargement has progressed so far that the pore spaces are completely filled up, a quartzite. By studying thin sections of this class of rocks, all stages of the process may be observed.

Precisely the same thing, on a larger scale, occurs when the solution enters fissures and open cavities—crystallization occurs around any nuclei which may happen to be present. The crystals formed in such openings may grow to large size—but they are, one and all, unsymmetrical, distorted, striated, and bounded by "rare" faces. For this there are several reasons. In the first place the nuclei are usually fragments of the wall rock, which are likely to be anything but regular in shape. And, as the solution is continually in more or less rapid motion, the crystals will adapt their sides to the shape of the nucleus, instead of boldly standing out in their normal, regular form.

A second factor influential in determining the irregularity of development of such crystals is the presence of foreign matter in the silica solution. It is a fact of common observation that small amounts of impurities in certain solutions will entirely alter the shape of the crystals forming therefrom. To illustrate this the following experiment was performed:

A saturated solution of common potash alum was prepared and divided into two parts. To one was added a few drops of a strong solution of potassium dichromate—sufficient to color the liquid rather strongly—while the other remained free from foreign substances. The two solutions, in similar vessels, were then placed side by side in a desiccator over sulphuric acid, and allowed to remain several weeks. The crystals which had deposited from the pure alum solution showed, of course, the usual octahedral form. But those from the liquid containing the impurity were perfect cubes without a trace of any octahedral face.

Just how such foreign matter acts to change the crystal form has never been satisfactorily made out. But we are reasonably safe in conjecturing that the extensive development of rare planes on quartz crystals is directly connected with the presence of impurities in the solution. Now such impurities would naturally be more liable to be present in the fissures which connect directly with the surface of the earth, than in cavities to enter which solutions must pass through the pore spaces in the rocks. We would expect, therefore, that the crystals formed in open fissures would be well provided with "rare planes."

The smoky color so common in this class of crystals also follows as the direct, logical consequence of the descent of the solution through fissures. It will be recalled that the carbon dioxide which worked the destruction of the feldspars, and so gave rise to the whole series of phenomena we are considering, came in part from the decomposition of the vegetable matter at the surface of the ground. But in this decomposition carbon dioxide is by no means the only product. Many complex organic compounds are also liberated, which, especially in the presence of potassium carbonate (one of the products of the reaction, as will be remembered) would dissolve in the water and be carried downward.

If the solution bearing them must pass through the pore spaces of the rocks, these compounds would be decomposed and filtered out before penetrating very far. But if, on the other hand, it enters the comparatively roomy cracks and fissures, where the descent is rapid, there is every chance for the introduction of the organic matter into the ozone where quartz crystals are forming, and accordingly these will become smoky.

You see, then, that there is a reason for the commonly noted fact that smoky crystals are likely to show rare planes, or, conversely, that highly modified crystals are likely to be smoky. It is, to repeat, because they have formed in fissures more or less directly connected with the surface of the earth. The frequent presence of inclusions, cappings, and etching figures on such crystals are clearly attributable to the same cause. For it is in these very fissures, where water is freely descending, that mud, asbestos, chlorite, or whatnot, would naturally be stirred up to fall upon the growing crystals, and then be covered up by later layers; or that the character of the solution would vary so as to produce the "capping" layers, or even to attack the previously formed crystals and create the depressions we call etching figures.

Now let us consider the second type of cavity in which crystals may form—the cavity shut in on all sides and not directly connected with any flowing stream of water. All rocks lying in the earth between certain limits are necessarily completely saturated with water. The upper limit is, of course, dependent on the position of springs and streams, and varies from 10 to 100 feet below the actual surface. The lower limit is determined by the temperature, for water turns into steam at 365 deg. Cent., no matter how great the pressure upon it. This temperature obtains, in general, only at depths of several miles. So for all practical purposes we may assume that the rocks we can study are normally saturated with water. Water fills, likewise, all cavities in these rocks; and this water is, further, continually in motion—extremely slow, to be sure, yet quite distinct and definite.

From the weathering rocks at or near the surface, a portion of the resulting colloidal silica solution passes through the pore spaces of the solid rocks below, enlarging the grains as it goes, perhaps, yet being still capable of depositing silica when it chances to enter a cavity. Here the crystals may grow quietly, slowly, and gradually. And it is here that they will assume, if not interrupted by contact with other crystals, all the symmetry and beauty of which the mineral quartz is capable.

Of course, many variations in form, habit, and distribution of faces are possible here also. For although some of the foreign salts will be removed by chemical reaction with the rock minerals with which they come into contact during the long, slow journey downward, other such material may well escape removal, and be present when the quartz is crystallizing. As mentioned before, little is known regarding the specific influence of different impurities, and from a theoretical point of view the whole subject is nothing but a vast field of speculation. However, we know from actual observation, for instance, that amethyst almost always occurs in short prismatic crystals; that the absence of prism faces is usually connected with the presence of hematite; and that clear quartz is generally provided with long, well developed prism planes.

The true reason for these variations in habit is, as noted above, at present unknown, but will surely not always remain so. The time will come when it shall be possible to prepare, at will, any of these forms. But with that, this discussion has nothing to do. Its purpose will be fulfilled if it has succeeded in furnishing some slight insight into the manner according to which, in nature, quartz crystals form.—Paper read before the Philadelphia Mineralogical Club.

ASIATIC SNAKES.

CONTRARY to general belief, says a writer in the Medical Journal, the python or boa constrictor rarely attacks people and is looked upon very differently by the people than are the hamadryad and cobra. The python will take up his abode in a neighborhood and will not disturb anything except the hen roosts; these he disturbs very much, as he has a great fondness for chickens, also for a stray dog or small goat. The Chinese kill the python to make medicine from the liver, which has a high repute among them. They also use the dried skin for medicine. Any Chinese drug shop in Siam will have a number of python skins for sale.

One of the most important things to know about snake bites is that the poisonous snakes, such as the hamadryad, cobra, etc., leave on the individual only the two punctures of the poison fangs, while the less poisonous and harmless snakes leave, besides the two punctures, the marks of adventitious teeth. This is most important in prognosis, as being called to see persons bitten who were showing great shock it helps physician and patient materially to assure the patient that while he may be very ill, he will not die.

There is only one snake in the Far East, that is, in India, Burma, Siam, and the Malay peninsula, that will always and at all times attack a man on sight. That is the hamadryad, justly more feared than any other animal that crawls. Fortunately for mankind they are not common, except in limited districts. They are so feared by all that the native shikarris or hunters will go miles out of their way to avoid the locality in which they are known to exist. The hamadryad will stalk a man as a tiger stalks his prey.

These two snakes, the hamadryad and cobra, cause the great annual death roll of India from snake bite, about 22,000 people last year. One reason for this great death roll is that Hindus and Buddhists will not kill the snakes, as it is against their religion to take life. The cobra will go away from you usually, except in the nesting season, and then he will attack you on sight if you disturb him or his mate. It is at this time that so many deaths take place among the Malays and Siamese, as it is coincident with the rice-planting season, and the peasants are busily at work in the rice fields. The cobra will bite under water, and many people are bitten on the foot or heel while planting rice. Death usually takes place in an hour or less. I have known a large buffalo to be bitten and die in fifteen minutes. It must have been bitten directly into a vein.

To Harden Plaster Casts.—Many efforts have been made to render plaster casts more durable, either by reinforcing them with wire, wood, or linen, or by coating the surface with some salt solution or fatty oil. None of these methods has proved fully satisfactory and it is therefore interesting to note a new process for the hardening of objects of plaster and magnesite, which has been protected by E. Hippe, of Frederiksberg. Melted rosin is used, but pure rosin cannot be used direct, as it possesses so high a temperature that the water of crystallization of the plaster would be driven off. In the new discovery the rosin is mixed with such substances that the mixture melts at 175 deg. to 200 deg. F. Suitable substances are petroleum, paraffin, various kinds of wax, etc. The objects to be hardened are either immersed in a bath of the mixtures or first impregnated with paraffin, etc., and then dipped in the other bath. Other substances, such, for instance, as sulphur, asphalt, etc., may be used to impart to the surface of the objects great hardness, density, chemical immunity, etc.

ENGINEERING NOTES.

A large area of peat land has been found in Madison County, Montana. The owner of a farm in the peat region has experimented in drying the peat, and samples of the fuel distributed in Virginia City have met with much favor. The fuel will be prepared in large quantity and can be sold at a low figure. A coal famine, due to lack of cars, has been threatening the region and the discovery of so cheap and efficient a substitute just at this time is considered a godsend.

During 1905, 5,240 persons were engaged in the United States in the manufacture of pens and pencils, and products to the value of $7,673,777 were manufactured. The manufacture of lead-pencil products was the most important branch of the industry, the production being valued at $4,425,896. Fountain and stylographic pens were second in importance in value of products, with $2,082,005; gold pens were next, with $692,029; and steel pens were last, with $473,847.

A mooring buoy, said to be the largest ever laid down, has just been put in position in the Mersey for the use of the Cunard liners "Lusitania" and "Mauretania." The buoy weighs some 17 tons. The mooring cables are of square section with stud links, and these, together with the anchors and shackles, aggregate 230 tons 13 hundredweight. The two shackles at the top of the buoy weigh 11½ hundredweight. The enormous size of the ships and the strong tidal currents—up to six or seven knots—that run in the river make the use of such massive tackle necessary to insure safety, for the vessels will spend practically the whole of their stay in the port at the buoy.—Mechanical Engineer.

The Great Western Railroad of Great Britain, which has the distinction of making the longest daily run without a stop, between London and Plymouth, a distance of 220 miles, has now established a new long-distance record in connection with their new Fishguard route to the south of Ireland. A train now runs in either direction once a day between London and the English port of Fishguard, a distance of 261½ miles, without a scheduled stop. The train makes the journey from London to Fishguard in 4 hours 48 minutes, equivalent to 52.6 miles per hour throughout the whole journey. As the latter half of the run involves the negotiation of the mountains of South Wales, where some of the grades are very heavy, the performance is a good one. The first 113 miles out of London are covered in 115 minutes. The return journey from Fishguard to London is similarly performed without a stop in 5 hours 2 minutes, the road being somewhat heavier in this direction. On the first run the train reached London eight minutes before the scheduled time.

A new method of utilizing peat bogs is the subject of an interesting paper which Dr. Caro, an eminent engineer of Berlin, presented to the second section of the eighth International Agricultural Congress of Vienna. In the first part of his paper he brings out facts which go to prove that the manufacture of peat briquettes or coke will scarcely have any other than a limited field, seeing that even when well dried, peat forms but an imperfect combustible and will not bear transportation to long distances. Regarding coke which is obtained from peat, it necessarily has a high price, and this is at a disadvantage when it comes to entering the market against coke made from coal. The question of drying the peat is a difficult one, seeing that to be used in the present processes it must not contain more than 15 or 20 per cent of water. For the sake of economy, it is hardly possible to dry the peat in practice except by a natural drying, and it is thus a hard matter to secure the combustible in a regular manner throughout the year. A process elaborated by the author in connection with Prof. Frank, of Charlottenburg, is designed to utilize the energy of the combustion of peat upon the spot, by producing gas from it in a suitable apparatus. Such gas will find various uses in the industries, and is especially adapted for operating an electric station of large size. With the present method, which also applies to the treatment of the mounds of waste material at the mouth of coal mines, we may utilize peat which contains 50 per cent of water and this can be obtained at all periods of the year. Besides, we are able to collect nearly all the nitrogen contained in the peat under the form of ammonia salts, and this can be utilized as a high-grade fertilizer. Where the percentage of nitrogen is not too low, the fertilizer products which are thus secured will represent a profit sufficient to cover the expense of handling the peat from the bogs, the drying, and the operation of the whole plant and give a profit besides, so that the gas may be said to be produced with no expense whatever. Such gas is very pure and it is specially adapted for running gas engines. Dynamos can thus be driven so as to obtain a source of current which will have a low price and can compete with current from turbine plants. Industries which might be established in the neighborhood of hydraulic plants would thus be attracted toward the regions of the peat supply. As the tracts which are freed from peat are more easily cultivated than before, the process is favorable to redeeming large tracts of land for agriculture in marsh land, and at the same time favor the industrial expansion of such regions.

ELECTRICAL NOTES.

It is reported that a Milan syndicate has obtained a concession to construct about 25 miles of electric tramway in the interior of the city and the suburbs. The same syndicate has obtained a concession to construct and work tramways in the popular seaside resort of Mondello.

A project has been laid before the Russian government for constructing an electric railway across the Caucasus mountains from Beslan to Vladikavkas on to Tiflis in Transcaucasia, a distance of 135 miles. The railway would be laid down within four and a half years of the date of the concession, which would be for eighty years.

A very ingenious use is now being made of the telephone in Norway, in connection with the fishing industry. A microphone, to magnify all the sounds received, is placed in a hermetically closed steel box, which is connected by means of electric wires to a telephone suitably located on board of the fishing smack. It is stated that in this way notice is given of the nature and approach, and also of the numbers, of shoals of fish. For instance, upon the approach of herrings or smaller members of the finny population of the deep, the microphone emits a kind of whistling sound. The cod notifies its vicinity by a curious howling sound, while fish of other kinds cause a hollow growling noise. These phenomena are attributed by the movements set up in the water by the action of the fins and gills of the fish. This enables the fishermen to deduce from the varying sounds the number, nature, and vicinity of the shoals of fish coming toward the smacks, and the men who go down to the sea in ships to procure our food are thus able to make due arrangements for securing a rich haul.

Observations made at the Astrophysical Observatory on the Pic du Midi, at an altitude of 2,877 meters during the days of August 20 and 21, 1907, to measure the electrical charges induced by the sun and moon, and the variations between the variations of the solar potential and that of the ground are described in Comptes Rendus. It was found that the sun induced a positive electric charge, which is greater when the air traversed by the solar radiation is dry, and which is entirely absorbed by any cloud which may pass in front of the solar disk, or by layers of humid air. The solar charge varied from 1 to 6 volts per minute. The moon produced a similar positive electrification. Variations of the ground potential are much more intense at high altitudes than at the earth's mean surface-level, approaching in some cases to 400 volts per minute.

J. Moscicki in Elektrotechnischer Zeitschrift gives a detailed account of his experiments which he began under Kowalski in 1900. He first tried, in his experimental plant of 100 horse-power at Vevey in 1903, many arcs in parallel, fed with alternating current at 50,000 volts, and 50 ~. Each arc flame was in series with a Moscicki condenser and an inductance. The arcs were grouped in two halves, between one earthed conductor and two mains joined to the secondary of the transformer. A condenser was inserted between the leads of each half, and a choking coil bridged over the outer mains to compensate for the very considerable phase lag ($\cos \phi = 0.2$); this compensation is stated to have been perfect. The furnace was cylindrical and provided with double walls, and a vertical double-wall partition dividing it in two halves. The aluminium electrodes were passed with their porcelain insulations through the walls; plates of mica were pushed over the tips to keep off the radiation from the arcs; the central partition was the other electrode. The air passed up the outer jacket, down between the double partition, and up again through the two rows of 90 arcs. Exaggerated accounts of Birkeland's yields induced the author to give up this complicated arrangement and to experiment with long flames produced in a kind of chimney. Finally, he adopted a rotating arc. The arc flame is produced between two vertical concentric copper electrodes and rotated by magnetic lines of force parallel to the axis, spinning round in the annular space; the electrodes and electro-magnets are cooled by water and oil. Using first alternating current, he required an ignition device for the arc which is described. But he now applies direct current, supplied by a compound dynamo at 1,500 volts or more. Only 1 per cent of the energy is absorbed in the auxiliary apparatus, and 525 kilogrammes of HNO_3 were obtained per kilowatt-year with the first laboratory furnace of 27 kilowatts. The simple furnace—dimensions not stated—would be suitable for working at higher pressures. The later patents of the author are in the name of the Initiativkomitee zur Herstellung von Stickstoffhaltigen Produkten Freiburg.

TRADE NOTES AND FORMULÆ.

Gray Stain for Ivory.—Lay the parts in a solution of 1 part of pyrogallic acid in 20 parts of water, for about 20 minutes, allow them to dry thoroughly, then immerse in a solution of 1 part of green vitriol in 25 parts of water.

Ocher Yellow Stain for Ivory.—(*a*) Allow the pieces to remain for a few minutes in very dilute solution of tin in hydrochloric acid (1 part muriate of tin, 30 parts of water) and then boil in a decoction of fustic (2 parts of rasped or ground fustic in 10 parts of water) filtered through a linen cloth. (*b*) Lay the pieces in 1 part of red chromate of potash dissolved in 18 parts of water for several hours and then place them in a bath of 2 parts of sugar of lead and 10 parts of distilled water.

Enamel for Waste Pipes, Very Durable.—The pipe is cleansed with dilute sulphuric acid and hot water and coated with the following ground coat: 34 parts of quartz, 15 parts of borax, 2 parts of carbonate of soda. The coating is heated in a muffle, about 110 inches in length, for 10 or 15 minutes. When cooled, the glaze coating is applied. The glaze for this purpose consists of feldspar 34 parts, quartz 19 parts, borax 24 parts, oxide of tin 16 parts, fluor-spar 4 parts, soda 9 parts, saltpeter 3 parts. The separate ingredients, after melting, are rubbed down fine with water, the mixture applied evenly and kept at white heat in the muffle for about 20 minutes.

To Stain Ivory Brown.—The objects are treated for twenty-four hours in a closely sealed vessel with petroleum ether, to remove all grease; then dried in the air and immersed for 10 to 15 minutes in a mixture of 40 parts of hydrochloric acid and 1,000 parts of water. After rinsing them off with water, they are dipped in a solution of 5 parts of permanganate of potash in 1,000 parts of water and left in it until the desired shade has been attained. Finally rinse them off in water and polish them. By dipping the pieces, before polishing, in a solution of 10 parts of fuchsine and 1,000 parts of water, the pure brown can be changed into a red brown. This process can also be employed for bone.

To Prepare Granulated Copper.—A communication on the granulation of solder appears in the Werkmeister und Industriebeamten-Zeitung, Reichenberg. The requirements are a fire for melting the solder, a crucible, and a piece of silk cloth or asbestos fabric. The silk or asbestos cloth must be about a yard long and 3/5 of a yard wide; it is gathered together in both hands at the small ends, so that the cloth forms a trough into which the molten solder is poured and in which it is continuously caused to roll from one end of the trough to the other. This is easily effected by alternately raising and depressing the ends of the trough. This rolling backward and forward is continued, until the solder assumes an appearance indicative of its approaching solidification. Then it must be allowed to collect in the center of the trough, the ends of the fabric are folded over, and the solder is rubbed between the hands in the cloth. Should the metal still be too hot, the hands may be protected by buckskin gloves.

By this simple method 2 pounds or more of solder can be granulated at once. The size of the grains is determined by the manner of manipulation, particularly, in rubbing up the solder, according to the more or less heavy pressure employed. The size of the mesh of the fabric is likewise a factor. The solder granules thus obtained are almost entirely uniform in size. If it is necessary to obtain absolutely equal-sized granules, they can be screwed in a wire sieve of the desired fineness of mesh. By this simple process, an expert workman will be able to granulate 135 pounds of solder per day. The satisfactory result of the granulation chiefly depends on the selection of the proper time, when the molten solder is of the right temperature to begin rubbing. If the temperature is too high, in addition to uneven granules, the hands will be affected; on the other hand, if the temperature of the metal is too low, large, uneven granulations will occur, which will be difficult, if not impossible, to rub up.

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